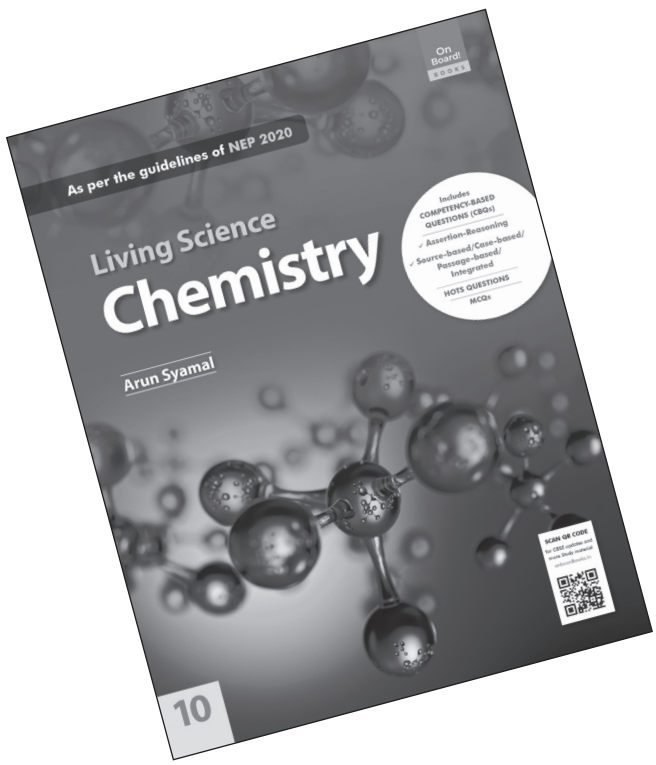
TEACHER'S HANDBOOK

CBSE Living Science
CHEMISTRY
Book 10



On Board! BOOKS

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Contents

CHAPTER – 1

CHEMICAL REACTIONS AND EQUATIONS

P. 15 Check Your Progress 1

a. $2Mg + O_2 \longrightarrow 2MgO$

b. $N_2 + 3H_2 \longrightarrow 2NH_3$

c. $2H_2 + O_2 \longrightarrow 2H_2O$

d. $3CaCO_3 + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3H_2O + 3CO_2$

e. $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$

P. 28 Check Your Progress 2

1. It is a displacement reaction. A red deposit of copper is formed on the surface of zinc due to the displacement of less reactive copper metal by the more reactive zinc metal. The blue colour of copper(II) sulphate solution disappears due to the formation of colourless zinc(II) sulphate.

$$\underset{\text{Blue}}{CuSO_4(aq)} + Zn(s) \longrightarrow \underset{\text{Red}}{Cu(s)} + \underset{\text{Colourless}}{ZnSO_4(aq)}$$

2. The arrangement of elements in the decreasing order of their electropositive character is called activity series of elements. In the activity series, the most electropositive element occurs at the top and the electropositive character of elements decreases down the series.

3. When an aqueous solution of potassium iodide is added to the aqueous solution of mercury(II) chloride, a scarlet-red precipitate of mercury(II) iodide is immediately formed.

$$\underset{\text{Mercury(II) chloride}}{HgCl_2(aq)} + \underset{\text{Potassium iodide}}{2KI(aq)} \longrightarrow \underset{\text{Mercury(II) iodide (scarlet-red ppt.)}}{HgI_2(s)} + \underset{\text{Potassium chloride}}{2KCl(aq)}$$

This is a double displacement reaction.

4. The chemical reactions in which the products are not capable of reacting among themselves to form the reactants back are called irreversible reactions. An irreversible reaction proceeds in the direction of the formation of products. For example,

$$Na_2CO_3(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2CO_3(aq)$$

5. In an activity series, a more active metal (placed higher in the activity series) can displace a less active metal from its solution. A metal in the activity series displaces a metal coming below. Zinc is placed higher than iron and copper. So it is more reactive than both iron and copper.

P. 32 Check Your Progress 3

1. Oxidation: A process which involves addition of oxygen or removal of hydrogen is called oxidation.

Reduction: A process which involves removal of oxygen or addition of hydrogen is called reduction.

2. $\underset{\text{Iron}}{4Fe(s)} + \underset{\text{Oxygen}}{3O_2(g)} + xH_2O(g) \longrightarrow \underset{\text{Rust (brownish-red)}}{2Fe_2O_3{\cdot}xH_2O}$

3. When a mixture of aluminium powder and powdered manganese (IV) oxide are heated, manganese (IV) oxide gets reduced to metallic manganese.

$$3MnO_2(s) + 4Al(s) \xrightarrow{\text{Heat}} 3Mn(l) + 2Al_2O_3(s)$$

Since in this reaction, oxygen is removed from manganese (IV) oxide, this is a reduction reaction.

4. Oxidising agent: A substance which causes addition of oxygen or removal of hydrogen from other substances is called oxidising agent.

Reducing agent: A substance which causes addition of hydrogen or removal of oxygen from other substances is called reducing agent.

5. Differences between oxidation and reduction

	Oxidation	Reduction
i.	It is a chemical reaction which involves addition of oxygen to a substance.	It is a chemical reaction which involves removal of oxygen from a substance.
ii.	It also involves removal of hydrogen from a substance.	It also involves addition of hydrogen to a substance.

P. 36 Check Your Progress 4

1. K > Ca > Mg > Pb > Hg

2. Metals are electropositive in character and non-metals are electronegative in character.

3. a. oxidising agent: Fe_2O_3, reducing agent: CO

b. oxidising agent: Br_2, reducing agent: H_2S

c. oxidising agent: MnO_2, reducing agent: Al

d. oxidising agent: ZnO, reducing agent: C

4. a., **c.** and **d.**

5. a. Combination reaction

b. Thermal decomposition reaction

c. Electrolytic decomposition reaction

d. Photochemical decomposition reaction

e. Displacement reaction

f. Double displacement reaction

g. Redox reaction

h. Double displacement reaction

i. Double displacement reaction

j. Double displacement reaction

6. a. The process of slow destruction of metals and manufactured materials containing metals due to their exposure to the environment is called **corrosion**.

b. The oxidative deterioration of oils and fats leading to stinking, smelling or tasting like rank stale fat is known as **rancidity**.

7. Conditions necessary for the occurrence of corrosion

The conditions necessary for the occurrence of corrosion are:

i. Presence of oxygen or air

ii. Presence of moisture or water vapour

8. The rate of corrosion is influenced by the following five factors:

i. Purity of metal

ii. Electropositive nature of metal

iii. Presence of reactive gases in the atmosphere

iv. Presence of salts in water

v. Temperature

9. The conditions necessary for rusting are:

i. Presence of air/oxygen

ii. Presence of water/moisture

10. The rate of rusting accelerates due to the following three factors:

i. Presence of reactive gases such as CO_2, SO_2, SO_3, NO, NO_2, HCl, NH_3, etc. in the atmosphere.

ii. Presence of salts in water. Rusting occurs faster in sea water than in distilled water.

iii. Presence of less electropositive metals as impurities in iron increases the rate of rusting.

11. Rancidity is an irreversible oxidation process. The unsaturated sites in fats and oils are susceptible to oxidation. Light and heat start the oxidation process in fats and oils by the formation of peroxide free radicals (R—O—O·) containing unpaired electron. These free radicals are very reactive due to the presence of unpaired electron and they split fats and oils into smaller organic compounds such as aldehydes, alcohols and carboxylic acids which cause the rancidity conditions that ultimately destroy the acceptability and usefulness of fats and oils.

12. An antioxidant is a substance which delays or prevents oxidation process of foods. The food grade antioxidants such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and propyl gallate (PG) are effective for the stabilisation of the edible fats and oils against the formation of oxidation products.

P. 39 EXERCISES

A. Objective Type Questions

I. Choose the most appropriate answer.

1. a	**2.** c	**3.** a	**4.** d	**5.** a
6. d	**7.** d	**8.** d	**9.** b	**10.** b
11. a	**12.** c	**13.** a	**14.** b	**15.** d
16. c	**17.** d	**18.** a	**19.** a	**20.** a
21. d	**22.** d	**23.** d	**24.** d	**25.** c
26. a	**27.** d	**28.** b		

II. Write True or False.

1. T	**2.** F	**3.** T	**4.** T	**5.** T
6. T	**7.** F	**8.** F	**9.** T	**10.** F
11. T	**12.** T			

III. Fill in the blanks.

1. reactivity

2. more, less

3. combination

4. precipitate

5. more

6. less, less

7. H_2S, Cl_2

8. C, PbO

9. combination

10. oxidised

11. light, heat

12. antioxidant

IV. Match the items in column A with those in column B.

1. b	**2.** a	**3.** d	**4.** c	**5.** f
6. g	**7.** e			

V. Balance the following unbalanced reactions.

1. $6MgO + 2N_2 \longrightarrow 2Mg_3N_2 + 3O_2$

2. $2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$

3. $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$

4. $2KMnO_4 \longrightarrow K_2MnO_4 + MnO_2 + O_2$

5. $3AgNO_3 + Al \longrightarrow Al(NO_3)_3 + 3Ag$

6. $2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$

7. $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

8. $Pb(CH_3COO)_2 + K_2CrO_4 \longrightarrow PbCrO_4 + 2CH_3COOK$

9. $Cr_2O_3 + 2Al \longrightarrow 2Cr + Al_2O_3$

10. $PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$

VI. Assertion–Reasoning Type Questions CBQ

1. c **2.** c **3.** c **4.** d **5.** d

6. b **7.** a **8.** d **9.** b **10.** c

VII. Very Short Answer Type Questions

1. A chemical change may be defined as a permanent change in which the original substance gives rise to one or more new substances with different properties.

2. A chemical equation in which the number of atoms of each element in the reactant side is equal to the number of atoms of each element in the product side is called a balanced chemical equation.

3. The conditions necessary for a chemical reaction to occur are known as reaction conditions.

4. Since iron is more electropositive, copper in copper sulphate will be replaced by iron and ferrous sulphate will be formed when iron nails are kept in copper sulphate solution. Hence, the blue colour of the solution will become pale green and copper will be deposited on iron nail.

$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$

5. A reaction in which an element and a compound react to form different substances by mutual exchange of atoms or groups of atoms is called a displacement reaction. For example,

$CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$

6. The reaction in which a compound breaks down to give two or more simpler substances is called a decomposition reaction. For example,

$CaCO_3 \longrightarrow CaO + CO_2$

7. It is observed that the white colour of silver chloride changes to grey in sunlight. This change of colour occurs due to the photochemical decomposition of silver chloride to metallic silver (grey) and chlorine in the presence of sunlight. This is photochemical decomposition reaction.

8. Decomposition reactions are called the opposite of combination reactions. In a decomposition reaction, a compound breaks down to give two or more simpler substances whereas in a combination reaction two or more elements or compounds combine to form a single compound.

Example of combination reaction:

$CaO + H_2O \longrightarrow Ca(OH)_2$

Example of decomposition reaction:

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

9. A reaction in which oxidation and reduction take place simultaneously is called oxidation-reduction or redox reaction.

Example: $Cl_2 + H_2S \longrightarrow 2HCl + S$

10. The activity series can be used to predict the products of displacement reactions.

11. H_2S is oxidised and Cl_2 is reduced.

12. H_2 is the reducing agent and CuO is the oxidising agent.

13. Aqueous hydrochloric acid can be oxidised using manganese (IV) oxide.

$4HCl + MnO_2 \longrightarrow MnCl_2 + 2H_2O + Cl_2$

14. A reducing agent in a redox reaction gets oxidised.

15. Displacement reaction

16. Displacement reaction

17. Oxygen can be removed from copper oxide by passing hydrogen gas over heated copper oxide.

$CuO + H_2 \xrightarrow[\text{reduction}]{\text{heat}} Cu + H_2O$

18. Double displacement reaction

19. Decomposition reaction

20. Oxygen can be removed from iron oxide by passing CO over heated iron oxide.

$Fe_2O_3 + 3CO \xrightarrow{\text{Heat}} 2Fe + 3CO_2$

21. Oxygen from manganese(IV) oxide can be removed by heating manganese oxide with aluminium powder in a crucible.

$3MnO_2 + 4Al \xrightarrow{\text{Heat}} 3Mn + 2Al_2O_3$

22. Hydrogen peroxide and potassium permanganate.

23. Calcium hydroxide reacts with carbon dioxide present in the air to form a thin layer of calcium carbonate on the walls. This is a combination reaction. The chemical reaction involved is as follows:

$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

24. Oxidation involves addition of oxygen or removal of hydrogen from a substance. Reduction involves addition of hydrogen or removal of oxygen from a substance.

25. HCl is being oxidised to Cl_2.

26. H_2O_2 is the oxidising agent and PbS is the reducing agent.

27. Yes

28. The process of coating iron with a thin layer of zinc to protect it from rusting is called galvanisation.

29. There are several methods for preventing rusting of iron. Two of them include surface coating with oil, paint or grease and galvanisation, i.e. coating of iron with a thin layer of zinc.

30. The oxidative deterioration of oils and fats leading to stinking, smelling or tasting like rank stale fat is known as rancidity. It occurs due to the oxidation of fat in the presence of light and heat, wherein peroxide radicals are formed from oxidation. These radicals are highly reactive and split fats and oils into smaller organic compounds such as aldehydes, alcohols and carboxylic acids. The production of these compounds makes the fat rancid.

31. Rancidity of fat can be prevented by adding small quantity of permitted synthetic antioxidants such as food grade BHT, BHA and propyl gallate; flushing of food packets with nitrogen gas before sealing and packaging the foods in nitrogen atmosphere can also be done.

32. Chilli powder is a common antioxidant used in our daily life.

33. Butylated hydroxytoluene and butylated hydroxylanisole are two synthetic antioxidants which are used in our food.

34. $Na_2CO_3(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

35. Double decomposition reactions involving ions are fast because they do not involve breaking or making of a covalent bond. Rather, there is only exchange of ions.

36. Brass utensils can be protected from corrosion by coating them with a thin layer of tin. This is called tinning.

37. Flushing of food packets with nitrogen removes any oxygen that may be present which creates an oxygen free environment, preventing oxidation of food.

38. Oxidation and reduction are complementary to each other as the substance which reduces another substance, itself undergoes oxidation. Oxidation and reduction occur simultaneously.

39. Since iron is more reactive than copper, there would be no change as copper cannot displace Fe from $FeSO_4$.

40. Oxidising agents: fluorine and hydrogen peroxide; reducing agents: sodium and carbon.

41. **i.** Thermal decomposition reactions

ii. Electrolytic decomposition reactions

iii. Photochemical decomposition reactions

42. As zinc is more reactive than copper, it will displace Cu and form zinc sulphate and copper.

$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$

43. Thermal decomposition

44. To prevent rancidity of potato chips.

45. The stale foods give bad smell and bad taste due to rancidity. The unsaturated sites in fats and oils are susceptible to oxidation. Fats and oils split into smaller organic compounds such as aldehydes, alcohols and carboxylic acids which cause the rancidity conditions that ultimately destroy the acceptability and usefulness of fats and oils. In rancid oils and fats, stearic acid is also produced by decomposition.

B. Short Answer Type-I Questions

1. Aluminium is more reactive because it is displacing manganese from MnO_2.

2. Fe_2O_3 is the oxidising agent and aluminium is the reducing agent because Al is removing oxygen from Fe_2O_3. Since Fe_2O_3 is adding oxygen to Al, it is the oxidising agent.

3. **a.** Displacement reaction

b. Combination reaction

4. Decomposition reaction can occur by heat, electricity and light and they are accordingly named as thermal decomposition, electrolytic decomposition and photochemical decomposition, respectively.

5. Addition of hydrogen is reduction. For example, when hydrogen gas is passed over heated copper oxide, the latter gets reduced to metallic copper. The reaction can be represented by the equation

$CuO + H_2 \xrightarrow{\text{Heat}} Cu + H_2O$

Removal of hydrogen is oxidation. For example, bromine water reacts with H_2S to form hydrogen bromide and sulphur. Thus, H_2S is oxidised to S.

$H_2S + Br_2 \longrightarrow 2HBr + S$

6. **a.** K > Ca > Zn > H > Cu

b. Ba > Na > Fe > Cu > Ag

7. An oxidising agent undergoes reduction in a redox reaction whereas a reducing agent undergoes oxidation.

8. $CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$

In the above redox reaction, copper oxide undergoes reduction as oxygen is being removed from it whereas hydrogen undergoes oxidation as oxygen gets added to it.

9. A reaction in which an acid reacts with a base to form a salt and water is called neutralisation reaction. For example,

$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$

$2KOH(aq) + H_2SO_4(aq) \longrightarrow K_2SO_4(aq) + 2H_2O(l)$

10. Rancidity and corrosion of metals are examples of redox reactions from everyday life.

11. a. A substance which causes addition of oxygen or removal of hydrogen from other substances is called oxidising agent.

b. A substance which causes addition of hydrogen or removal of oxygen from other substances is called a reducing agent.

12. a. The process in which a compound in an aqueous solution or in a molten state is decomposed by passage of electricity is called electrolytic decomposition or electrolysis. For example,

$2H_2O \xrightarrow[\text{electricity}]{H^+} 2H_2 + O_2$

b. The reaction in which a compound breaks down by heat to give two or more simpler substances is called thermal decomposition reaction. For example,

$MgCO_3 \xrightarrow{\Delta} MgO + CO_2$

13. Oxidation and reduction occur simultaneously because a substance which oxidises another substance, itself undergoes reduction. For example, in the given reaction

$ZnO + C \longrightarrow Zn + CO$, carbon is the reducing agent and removes oxygen from ZnO. But in the process, oxygen gets added to carbon, hence, carbon undergoes oxidation.

14. An aqueous solution of sodium sulphate reacts with an aqueous solution of barium chloride to form a white precipitate of barium sulphate.

The balanced chemical equation for the reaction is:

$Na_2SO_4(aq) + BaCl_2(aq) \longrightarrow 2NaCl(aq) + BaSO_4(\downarrow)$

This is a double displacement/precipitation reaction.

If the reactants are in the solid state, the reaction will not take place.

C. Short Answer Type-II Questions

1. The limitations of a chemical equation are:

i. A chemical equation does not indicate the physical states of the reactants and products.

ii. It also does not indicate whether the reaction is accompanied by evolution of a gas or formation of a precipitate.

These limitations can be removed by stating the states of matter of the substances in brackets and indicating the precipitate formed or gas released during a chemical reaction.

2. a. $2KBr(aq) + BaI_2(aq) \longrightarrow 2KI(aq) + BaBr_2(s)$

Double displacement reaction

b. $ZnCO_3(s) \longrightarrow ZnO(s) + CO_2(g)$

Decomposition reaction

c. $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$

Combination reaction

d. $Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$

Displacement reaction

3. A chemical reaction in which heat is evolved is called an exothermic reaction. For example,

$C + O_2 \longrightarrow CO_2 + \text{heat}$

A chemical reaction in which heat is absorbed is called an endothermic reaction. For example,

$C + 2S + \text{heat} \longrightarrow CS_2$

4. In a decomposition reaction, a compound breaks down to give two or more simpler substances whereas in a combination reaction, two or more substances combine to give rise to new substances. For example, decomposition reaction of $MgCO_3$ can be represented as:

$MgCO_3 \xrightarrow{\Delta} MgO + CO_2$

A reversal of the same reaction can be combining of MgO and CO_2 to form $MgCO_3$. Hence, decomposition reactions are called the opposite of combination reactions.

5. a. An example of a combination reaction of an element and a compound is:

$2NO + O_2 \longrightarrow 2NO_2$

b. An example of a double decomposition reaction is:

$NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$

c. An example of a decomposition reaction of a compound into two compounds is:

$ZnCO_3 \longrightarrow ZnO + CO_2$

6. Corrosion is a spontaneous and irreversible process because oxygen and moisture are invariably present in the atmosphere and hence

the formation of a metal oxide is spontaneous. The reversal of corrosion, i.e. splitting of metal oxide to form metal and oxygen is not feasible as oxygen is highly electronegative. Another example of an irreversible process is the conversion of milk into curd.

7. a. At cathode, H_2 is evolved and at anode O_2 is evolved.

b. At cathode, H^+ ion takes two electron to convert itself into H_2 gas. 2 moles of H^+ gives 1 mole of H_2.

$2H^+(aq) + 2e^- \longrightarrow H_2(g)$

At anode, OH^- ion releases two electrons to convert into water and O_2. 2 moles of OH^- gives 0.5 mole of O_2. This is why, volume of gas collected at one electrode is double than the another.

c. Acid is added to make the water conduct electricity as the distilled water is a non-conductor of electricity.

8. This statement is true. Passing of electricity through molten sodium chloride breaks it into the individual elements, hence it is a decomposition reaction, more specifically electrolytic decomposition. Combination of sodium and chlorine results in the formation of sodium chloride, hence, it is a combination reaction.

9. Four different types of reactions are:

i. Combination reactions

ii. Decomposition reactions

iii. Displacement reactions

iv. Double displacement reactions

In double displacement reactions, an exchange of ion occurs between the reactants, resulting in the formation of two new compounds. For example,

$$NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$$

10. Decomposition reactions can be further classified into:

i. Thermal decomposition reaction

$2KClO_3(s) \xrightarrow{\Delta} 2KCl(s) + 3O_2(g)$

ii. Electrolytic decomposition reaction

$2Al_2O_3(l) \xrightarrow{\text{electricity}} 4Al(l) + 3O_2(g)$

iii. Photochemical decomposition reaction

$2AgCl(s) \xrightarrow{\text{sunlight}} 2Ag(s) + Cl_2(g)$

11. A reaction in which an element and a compound react to form different substances by mutual exchange of atoms or groups of atoms is called a displacement reaction.

$CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$

A reaction in which two compounds react to form two new compounds by mutual exchange of atoms or groups of atoms is called a double displacement or double decomposition reaction.

$NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$

12. A reaction in which oxidation and reduction take place simultaneously is called oxidation–reduction or redox reaction.

Magnesium burns in the presence of oxygen to form solid magnesium oxide. Since oxygen is added to magnesium, it is oxidised.

$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

13. Sodium burning in chlorine gas can be represented by the following chemical equation:

$2Na + Cl_2 \longrightarrow 2NaCl$

Chlorine is the oxidising agent and sodium gets oxidised to form sodium chloride.

14. a. Decomposition reaction

b. Double displacement reaction

c. Decomposition reaction

d. Displacement reaction

15. a. In a reaction of a solution of lead nitrate with a solution of potassium iodide, a double displacement reaction takes place leading to the formation of potassium nitrate and yellow precipitate of lead iodide.

b. The equation representing this reaction will be:

$$Pb(NO_3)_2 + 2KI \longrightarrow PbI_2 + 2KNO_3$$

16. a. i. Double displacement reaction

ii. Combination reaction

iii. Decomposition reaction

iv. Displacement reaction

b. $3BaCl_2 + Al_2(SO_4)_3 \longrightarrow 3BaSO_4 + 2AlCl_3$

17. a. The colour of the precipitate formed is yellow. The compound precipitated is lead iodide.

b. $Pb(NO_3)_2 + 2KI \longrightarrow PbI_2 + 2KNO_3$

c. Double displacement reaction and precipitation reaction.

18. a. $3H_2 + N_2 \longrightarrow 2NH_3$

b. $2H_2S + 3O_2 \longrightarrow 2H_2O + 2SO_2$

c. $3BaCl_2 + Al_2(SO_4)_3 \longrightarrow 2AlCl_3 + 3BaSO_4(\downarrow)$

d. $2K + 2H_2O \longrightarrow 2KOH + H_2(\uparrow)$

19. a. Two observations for the given reaction are:

i. Change in state and colour

ii. Evolution of gas

b. Decomposition reaction

c. $2FeSO_4(s) \xrightarrow{Heat} Fe_2O_3(s) + SO_2(g) + SO_3(g)$

20. a. The black coloured substance is formed due to the reaction of copper with air.

b. Copper reacts with oxygen present in air to form a black substance called copper oxide.

c. $2Cu + O_2 \longrightarrow 2CuO$

d. On passing hydrogen gas (H_2) over the heated material.

21. Quicklime is calcium oxide. When calcium oxide is mixed with water, the reaction that takes place can be represented as:

$CaO + H_2O \longrightarrow Ca(OH)_2 + Heat$

This reaction is an exothermic reaction and thus is accompanied by the evolution of heat. This is why, she must have noticed it boiling even when it was not heated.

22. When 2 g AgCl is kept in sunlight then it will break down into Ag and Cl_2. The colour of silver chloride turns grey.

The given reaction can be represented as:

$2AgCl(s) \xrightarrow{sunlight} 2Ag(s) + Cl_2(g)$

White Grey

This type of reaction is an example of photochemical decomposition reaction.

23. a. The given reaction is a displacement reaction in which more reactive zinc will displace less reactive silver from silver nitrate solution.

$Zn(s) + 2AgNO_3(aq) \longrightarrow Zn(NO_3)_2(aq) + 2Ag(s)$

b. The given reaction is a double displacement reaction.

$2KI(aq) + Pb(NO_3)_2(aq) \longrightarrow 2KNO_3(aq) + PbI_2(s)$

24. When 1g of copper powder is taken in a china dish and heated, a black coloured substance is formed. This substance is copper oxide.

$2Cu + O_2 \longrightarrow 2CuO$

The copper gets oxidised to copper oxide.

When hydrogen gas is passed over this heated substance CuO, copper metal is obtained.

The black coloured CuO is reduced and reddish-brown colour Cu metal is produced.

$CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$

25. a. Reducing agent – H_2S, oxidising agent – SO_2, substance oxidised – hydrogen sulphide, substance reduced – sulphur dioxide.

b. Reducing agent – Al, oxidising agent – Cr_2O_3, substance oxidised – Al, substance reduced – Cr_2O_3.

c. Reducing agent – PbS, oxidising agent – H_2O_2, substance oxidised – PbS, substance reduced – H_2O_2.

26. a. Corrosion: The process of slow destruction of metals and materials containing metals due to their exposure to the environment is called corrosion. For example, rusting of iron is an example of corrosion.

b. Rancidity: The oxidative deterioration of oils and fats leading to stinking, smelling or tasting like rank stale fat is called rancidity. For example, when food containing fats and oil is kept in open for some time, it develops a stale taste.

D. Long Answer Type Questions

1. The arrangement of elements in the decreasing order of their electropositive character is called the activity series of metals. Reaction **a.** will take place because zinc is more reactive than copper. Reaction **c.** will take place because Zn is more reactive than iron. Reaction **b.** will not take place because Fe is less reactive than Zn and hence cannot replace Zn.

2. a. Double displacement reaction

$BaCl_2 + CuSO_4 \longrightarrow BaSO_4 + CuCl_2$

b. Oxidation reaction/combination reaction

$2Cu + O_2 \longrightarrow 2CuO$

c. Decomposition reaction

$2FeSO_4 \xrightarrow{Heat} Fe_2O_3 + SO_2 + SO_3$

d. Displacement reaction

$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$

e. Combination reaction

$CaO + H_2O \longrightarrow Ca(OH)_2 + Heat$

3. a. A reaction in which two ionic compounds in the solution react to form two other compounds by mutual exchange of atoms or groups of atoms is called double displacement or double decomposition reaction.

When an aqueous solution of silver nitrate is treated with an aqueous solution of sodium chloride, a white precipitate of silver chloride is formed.

$NaCl(aq) + AgNO_3(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$

Sodium chloride — Silver nitrate — Silver chloride (white precipitate) — Sodium nitrate

b. i. The given reaction is a combination reaction. A reaction in which two or more reactants combine to form a single product is known as a combination reaction.

ii. $CaO + H_2O \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \text{Heat}$

iii. A large amount of heat is evolved in the given reaction and this is an exothermic reaction.

4. Refer Activity 11 from page 21 of the textbook.

5. a. See Activity 7 on page 18 and 19 of the textbook.

b. See Figure 1.5 on page 19 of the textbook.

c. The balanced chemical equation for the given reaction is

$$2Pb(NO_3)_2(s) \xrightarrow{\Delta} 2PbO(s) + 4NO_2(g) + O_2(g)$$

6. The reaction in which two or more elements or compounds combine together through chemical bonds to form a single compound is called a combination reaction. For example, when zinc is burnt in oxygen, it combines with oxygen to form solid zinc(II) oxide.

$2Zn(s) + O_2(g) \longrightarrow 2ZnO(s)$

During a combination reaction, the chemical bonds between the atoms of the reactants are broken and new chemical bonds are formed.

The reaction in which a compound breaks down to give two or more simpler substances is called a decomposition reaction. For example, magnesium carbonate on heating strongly at 1000 °C gives magnesium oxide and carbon dioxide.

$MgCO_3(s) \xrightarrow{\Delta} MgO(s) + CO_2(g)$

In a decomposition reaction, there is only one reactant. A decomposition reaction is the reverse of combination reaction. Decomposition reactions are further classified into:

i. Thermal decomposition reactions

ii. Electrolytic decomposition reactions

iii. Photochemical decomposition reactions

7. A reaction in which oxidation and reduction take place simultaneously is called oxidation-reduction or redox reaction. For example,

$Cl_2 + H_2S \longrightarrow 2HCl + S$

$CuO + H_2 \longrightarrow Cu + H_2O$

A displacement reaction can be a redox reaction. It is exemplified in the above examples.

Corrosion of metals and rancidity are two examples of redox reactions from everyday life.

E. Source-based/Case-based/Passage-based/Integrated Assessment Questions CBQ

1. a. iii. **b.** iii. **c.** iii. **d.** i. **e.** ii.

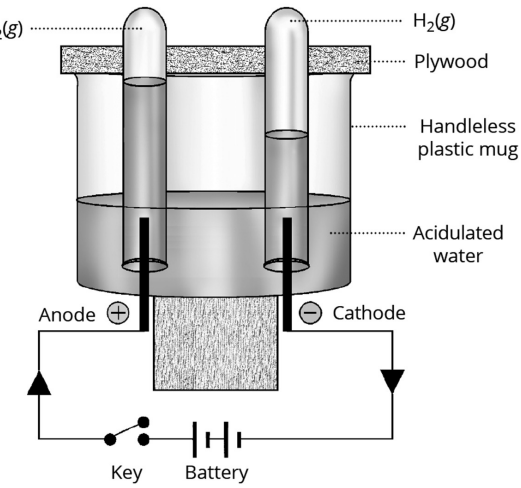
2. a. ii. **b.** iii. **c.** iii. **d.** i. **e.** iv.

3. a. iv. **b.** iv. **c.** iii. **d.** iv. **e.** i.

4. a. iv. **b.** iii. **c.** iii. **d.** iii. **e.** iii.

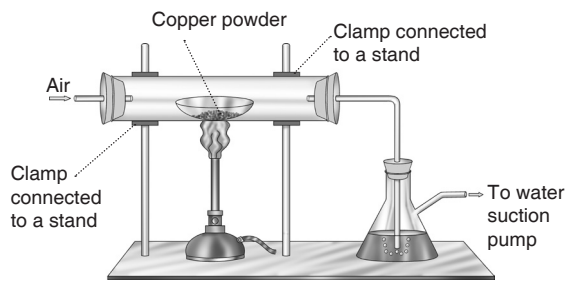
F. Diagrammatic Questions

1.

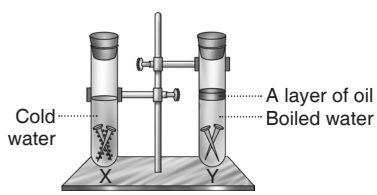


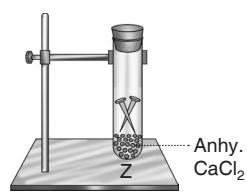
Electrical decomposition of acidulated water to produce hydrogen and oxygen

2. Oxidation of heated copper powder by oxygen:



3. Test tube containing cold water has both air and moisture in it. So, rust is formed on the iron nails. Test tube containing boiled water has only water in it, so no rust is formed. Test tube containing anhydrous calcium chloride is devoid of moisture, so no rust is formed. This shows that both air and moisture are essential for rusting.





G. Higher Order Thinking Skills (HOTS) Questions

1. **a.** H_2S is undergoing oxidation.

b. Cl_2 is undergoing reduction.

2. The reaction is a decomposition reaction and X is silver. Silver chloride when exposed to sunlight decomposes to form silver and chlorine. The white colour of silver chloride changes to grey colour as silver is formed.

3. Compound A is ferrous sulphate. Compound B is iron (III) oxide.

$$2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$$

4. A is silver nitrate. On addition of sodium bromide, silver bromide and sodium nitrate are formed. Silver bromide is compound B which decomposes on exposure to sunlight, liberating bromine (reddish–brown gas).

$$AgNO_3 + NaBr \longrightarrow AgBr + NaNO_3$$

$$2AgBr \xrightarrow{\text{sunlight}} 2Ag + Br_2$$

5. The compound A is water which on electrolytic decomposition forms hydrogen and oxygen and the volume of hydrogen is double that of oxygen. B is oxygen as it supports combustion and is essential for life and C is hydrogen as it is highly combustible.

6. Metal A is iron. Blue-coloured solution B is copper sulphate solution. When blue coloured solution B is stored in a container made up of metal A (iron), ferrous sulphate (green colour) and copper are formed. So, metal C is copper.

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

It is a displacement reaction.

7. Metal A is magnesium and B is hydrogen gas.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

Since, magnesium displaces hydrogen from HCl, it is more reactive than hydrogen.

8. **a.** Solid A is assumed to be MnO_2 and solid B to be Aluminium (Al). When the mixture of MnO_2 and Al is heated, manganese (Mn) is produced in molten state and aluminium oxide (Al_2O_3) floats over it. Mn is produced in the molten state as a lot of heat energy is released in the process.

The balanced chemical equation involved is

$$3MnO_2(s) + 4Al(s) \xrightarrow{\text{Heat}} 3Mn(l) + 2Al_2O_3(l) + \text{Heat}$$

The reaction is an exothermic reaction.

b. The types of reaction under which the above reaction can be classified are:

i. Redox reaction

ii. Displacement reaction

9. Metal X is lead. B is nitrogen dioxide

$$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + O_2$$

10. $Pb(NO_3)_2 + 2KI \xrightarrow{\Delta} \underset{\text{yellow ppt.}}{PbI_2} + 2KNO_3$

This is a double displacement reaction.

11. Oil and fat containing food items are readily oxidised. This results in rancidity of oil and fat, i.e. their smell and taste change. So, the oil and fat containing food items are flushed with nitrogen to prevent their oxidation.

12. **a.** Carbon is the reducing agent.

b. PbO is the oxidising agent.

13. Nails in test tube A will undergo corrosion because corrosion needs the presence of both air and moisture and both are present in test tube A. Test tube B has moisture but no air and test tube C has air but no moisture.

14. **a.** If Fe is added to $CuSO_4$ solution, the blue colour will change to pale green as Fe will displace Cu from the solution.

b. No change will be observed as Cu is less reactive than iron and cannot displace iron from the solution.

c. Zn will displace Ag. This is because Zn is more reactive than Ag and hence it will displace Ag from the solution.

15. To prevent photodecomposition.

H. Value-Based Questions (Optional)

1. **a.** The conditions necessary for the occurrence of corrosion are:

i. Presence of oxygen or air

ii. Presence of moisture

b. Spontaneous processes do not require energy input to proceed, whereas non-spontaneous processes do. So, rusting is a spontaneous process.

c. The process of slow destruction of metals and materials containing metals on exposure to environment is called corrosion. So, rusting of iron is a corrosion process.

d. The following methods are commonly used for prevention of corrosion:

i. Protection by coating the metal surface with oil or grease.

ii. Protection by covering metal surface with paint, plastic, rubber or ceramic.

e. Sharing knowledge, scientific temperament, etc.

2. a. Storing foods containing fats and oil in airtight containers slows down their oxidation. So, Manisha advised Nandini to use airtight container for storing butter to prevent its rancidity.

b. Sharing knowledge, scientific temperament, etc.

3. a. For the safety of eye during experiment.

b. Rahul has caring nature and knows how to use his knowledge.

c. Helping nature, care for others and scientific temperament, etc.

4. a. $2FeSO_4(s) \xrightarrow{\Delta} Fe_2O_3(s) + SO_2(g) + SO_3(g)$

Iron(II) sulphate — Iron(III) oxide

b. Decomposition reaction

c. Sharing knowledge, helping nature, etc.

P. 50–51 TEST PAPER

1. a. A precipitate is an insoluble product formed during the reaction of two ionic compounds in an aqueous solution.

b. A process which involves addition of oxygen or removal of hydrogen is called oxidation.

c. A process which involves addition of hydrogen or removal of oxygen is called reduction.

2. Oxidation and reduction are complementary to each other as the substance which reduces another substance, itself undergoes oxidation. Oxidation and reduction occur simultaneously. Hence, they are complementary to each other.

3. A reaction in which an element and a compound react to form different substances by mutual exchange of atoms or groups of atoms is called displacement reaction. For example,

$$CuSO_4 + Fe \longrightarrow FeSO_4 + Cu$$

4. Decomposition reactions are the reverse of combination reactions.

5.

	Oxidising agent	Reducing agent	Substance oxidised	Substance reduced
a.	MnO_2	HCl	HCl	MnO_2
b.	CuO	H_2	H_2	CuO
c.	Br_2	H_2S	H_2S	Br_2
d.	O_2	P_4	P_4	

6. When iron filings are added to copper sulphate solution, iron replaces copper from the solution and forms ferrous sulphate as iron is more reactive than copper. Hence, the blue colour disappears.

7. a. It is a displacement reaction (chlorine replaces iodine) **b.** It is a combination reaction (copper and sulphur combine to form copper sulphide.

8. It is a decomposition reaction.

9.

Displacement	Double displacement
A reaction in which an element and a compound react to form different substances by mutual exchange of atoms or groups of atoms is called displacement reaction.	A reaction in which two compounds react to form two new compounds by mutual exchange of atoms or groups of atoms is called a double decomposition or double displacement reaction.
Each side has one element and one compound.	Compounds are present on both sides.
Example: $2AgNO_3(aq) + Cu(s) \longrightarrow Cu(NO_3)_2(aq) + 2Ag(s)$	Example: $Na_2SO_4(aq) + BaCl_2(aq) \longrightarrow BaSO_4(s) + 2NaCl(aq)$

CHAPTER – 2

ACIDS, BASES AND SALTS

P. 73 Check Your Progress 1

1. HCl is a stronger acid because it ionises completely to H^+ and Cl^- ions while carbonic acid (H_2CO_3) dissociates partially, so it is a weak acid.

2. The ions formed are:

$$HCl(aq) + H_2O(l) \longrightarrow H_3O^+(aq) + Cl^-(aq)$$

$$H_2SO_4(aq) + 2H_2O(l) \longrightarrow 2H_3O^+(aq) + SO_4^{2-}(aq)$$

$$CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

$$NH_4OH(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

3. The equation for the dissociation of calcium hydroxide in aqueous solution is:

$$Ca(OH)_2(s) \xrightarrow{H_2O} Ca^{2+}(aq) + 2OH^-(aq)$$

4. *pH* is defined as the logarithm of the reciprocal of hydrogen ion concentration. Higher the concentration of H^+ ions, the lower is the *p*H.

5. **Acidic:** Solutions C and E

Basic: Solutions A and B

Neutral: Solution D

6. Plants grow best when *p*H of the soil is close to 7. Soils having *p*H values in the alkaline region or highly acidic region are not favourable for the growth of plants.

7. **i.** *p*H range is essential for the survival of plants and animals. Living organisms can survive only in a narrow *p*H range, for example, our body works within the *p*H range of 7.0 – 7.8. Acid rain with *p*H less than 5.6 affects plants as well as the aquatic life.

ii. *p*H range is useful in the process of digestion too. Digestion of food in our stomach takes place in the presence of HCl. *p*H of gastric juice is 1.0 – 2.0 because of HCl. When there is excess of acid in the stomach, there is pain and irritation. This can be prevented by taking antacids [$Mg(OH)_2$ or milk of magnesia] which can neutralise the excess acid.

8. **a.** sulphuric acid

b. nitric acid

c. dissociation, ionisation

9. 7 – 7.5

10. In the fluoride toothpastes, sodium fluoride is added to prevent tooth decay. Sodium fluoride reacts with calcium phosphate present in our teeth to form insoluble calcium fluoride which gets coated on our teeth. As a result, acids cannot attack calcium phosphate.

$$Ca_3(PO_4)_2 + 6NaF \longrightarrow 3CaF_2 + 2Na_3PO_4$$

P. 78 Check Your Progress 2

1. **a.** $2NaOH + H_2CO_3 \longrightarrow 2H_2O + Na_2CO_3$

b. $Mg(OH)_2 + 2HNO_3 \longrightarrow Mg(NO_3)_2 + 2H_2O$

c. $3KOH + H_3PO_4 \longrightarrow K_3PO_4 + 3H_2O$

d. $2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

e. $NH_4Cl + NaOH \longrightarrow NH_3 + H_2O + NaCl$

f. $FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 + 3NaCl$

2. A base is a substance which produces hydroxyl ions in solution. For example, NaOH, KOH, etc.

3. **a.** copper(II) hydroxide

b. ammonium hydroxide

c. iron(III) hydroxide

d. ammonium hydroxide

e. condiment

f. foaming agent

g. sour, bitter

4. **a.** F **b.** F **c.** F **d.** T **e.** T **f.** T

P. 87-88 Check Your Progress 3

1. **Acid salt:** $NaHCO_3$, NH_4HSO_4, $(NH_4)_2SO_4$ and NaHS

Basic salt: Na_2S and HCOONa

2. **a.** acidic

b. basic

c. soda-acid

3. **a.** F **b.** F **c.** F

4. Uses of sodium hydrogencarbonate ($NaHCO_3$): $NaHCO_3$ is used as an antacid, in fire extinguishers, for the preparation of soft drinks, in fruit salts, in baking powder, etc.

P. 92-93 Check Your Progress 4

1. **a.** $Cu + H_2SO_4(dil.) \longrightarrow$ No reaction

b. $CuCO_3 + 2HNO_3 \longrightarrow Cu(NO_3)_2 + CO_2 + H_2O$

c. $Ca(HCO_3)_2 + 2HCl \longrightarrow CaCl_2 + 2CO_2 + 2H_2O$

d. $3MgCO_3 + 2H_3PO_4 \longrightarrow Mg_3(PO_4)_2 + 3H_2O + 3CO_2$

2. Plaster of Paris can be prepared by heating gypsum at 373 K. The equation for the reaction is as follows:

$$\underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O} \xrightarrow{\text{Heat}} \underset{\text{Plaster of Paris}}{CaSO_4 \cdot \frac{1}{2} H_2O} + 1\frac{1}{2} H_2O$$

3. Refer Activity 28 from page 88 of the textbook.

4. A salt is an ionic compound formed by the partial or complete replacement of the ionisable hydrogen ions of an acid by cations. Two salts that are insoluble in water are lead sulphate and silver chloride.

5. The fixed number of water molecules which remain in the crystal lattice of crystalline salts are called water of crystallisation. The water of crystallisation is often responsible for the colour and crystalline nature of a salt. It can usually be removed from a crystalline salt by heating the salt at a temperature above 100°C. When the crystalline salt loses its water of crystallisation, it becomes amorphous.

$$\underset{\text{Washing soda (crystalline)}}{Na_2CO_3 \cdot 10H_2O} \xrightarrow[-9H_2O]{373\ K} \underset{\text{(amorphous)}}{Na_2CO_3 \cdot H_2O}$$

$$Na_2CO_3 \cdot H_2O \xrightarrow[-H_2O]{\text{above } 373\ K} \underset{\text{Soda ash (amorphous)}}{Na_2CO_3}$$

6. a. calcium chloride

b. FeS

c. NH_4Cl

d. lead(II) nitrate

e. photography

f. detergents

7. a. F **b.** F **c.** F **d.** F **e.** T **f.** T

P. 95 EXERCISES

A. Objective Type Questions

I. Choose the most appropriate answer.

1. d	**2.** d	**3.** d	**4.** a	**5.** d
6. d	**7.** c	**8.** c	**9.** a	**10.** c
11. d	**12.** b	**13.** d	**14.** c	**15.** c
16. b	**17.** d	**18.** d	**19.** a	**20.** c
21. b	**22.** a	**23.** c	**24.** a	

II. Write True or False.

1. F	**2.** F	**3.** T	**4.** T	**5.** T
6. F	**7.** T	**8.** F	**9.** T	**10.** F
11. F	**12.** F	**13.** F	**14.** T	**15.** T
16. T				

III. Fill in the blanks.

1. acid salt **2.** hydronium, positive

3. acid, metal **4.** $CaCl_2$

5. $MgCO_3$ **6.** $NaHCO_3$

7. KCl **8.** carbonic acid

9. potassium sulphate **10.** sulphuric acid

IV. Match the items in column A with the items in column B.

I. 1. e **2.** c **3.** d **4.** b **5.** a

II. 1. b **2.** a **3.** e **4.** c **5.** d

V. Cross out the incorrect statement.

1., **2.** and **4.** are incorrect statements.

VI. Balance the following unbalanced equations.

1. $2NaHCO_3 \xrightarrow{Heat} Na_2CO_3 + H_2O + CO_2$

2. $Cu + 2H_2SO_4 \longrightarrow CuSO_4 + 2H_2O + SO_2$

3. $Pb(OH)_2 + 2HNO_3 \longrightarrow Pb(NO_3)_2 + 2H_2O$

4. $4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$

5. $Ca_3(PO_4)_2 + 6HCl \longrightarrow 3CaCl_2 + 2H_3PO_4$

VII. Assertion–Reasoning Type Questions CBQ

1. c	**2.** a	**3.** a	**4.** c	**5.** d
6. b	**7.** c	**8.** c	**9.** a	**10.** a

VIII. Very Short Answer Type Questions

1. Vinegar and lemon.

2. Soaps and baking soda.

3. An acid is a substance which produces hydronium ions when dissolved in water.

4. A base is a substance which produces hydroxyl ions when dissolved in water.

5. An indicator is a substance which changes to a characteristic colour in the presence of a particular concentration of ions such as H^+ and OH^- ions. Two examples of indicators are phenolphthalein and methyl orange.

6. Refer Activity 9 from page 62 of the textbook.

7. Sample of concentrated H_2SO_4 will have a higher H^+ ion concentration and a lower *p*H number.

8. $NaHCO_3$

9. The *p*H of coffee is 4.5 to 5.5 and that of blood is 7.36 to 7.42.

10. A mixture of several indicators which can show different colours at different concentrations of hydrogen ion in a solution is called universal indicator.

11. Hydrogen carbonate–carbonic acid system.

12. Uric acid

13. Lactic acid

14. 7 to 7.5. This *p*H is called biological *p*H.

15. Oxalic acid

16. Calcium hydroxide, quicklime and calcium carbonate.

17. In case of alkaline soils, soils are not usually treated with acidic substances since it is impractical and uneconomical. Rather the top soil is replaced by soil with *p*H value in less acidic region.

18. Yes. Copper (II) hydroxide can be called an alkali because it can produce hydroxyl ions.

19. $2Cu_2O \xrightarrow{Heat} 4Cu + O_2$

$4NaOH \xrightarrow{Heat} 2Na_2O + 2H_2O$

20. Baking soda. Because the sting of bee contains formic acid and baking soda is a basic substance which neutralises the acid.

21. Normal salt – NaCl

Acid salt – $NaHCO_3$

Basic salt – Pb(OH)Cl

22. Chlor-alkali process (which involves production of sodium hydroxide from sodium chloride) is so called because chlor stands for chlorine and alkali stands for sodium hydroxide.

23. Calcium hydroxide and chlorine gas are used for the production of bleaching powder.

24. Sodium chloride

25. Ammonium chloride solution is weakly acidic because it is formed by the neutralisation of a strong acid (HCl) and weak base (NH_4OH).

26. Dilute sulphuric acid is a stronger acid than concentrated acetic acid because it releases more H^+ ions in water than acetic acid. The more the number of H^+ ions released in water, the stronger is the acid.

27. On the basis of its concentration in solution.

28. Oxalic acid.

29. Acids should be handled with care because they are highly corrosive in nature. For example, touching concentrated nitric acid with palm leads to the formation of a yellow stain on the palm and the stain stays for about seven days, and it peels out along with the yellow skin. Even dilute acids should be handled with proper care.

30. An acid which dissociates to a large extent in a solution is called strong acid and an acid which undergoes ionisation only to a small extent is called a weak acid.

31. The formation of salt and water when an acid reacts with a base is called neutralisation. Heat is liberated in a neutralisation reaction.

32. Sodium hydrogen sulphate, $NaHSO_4$

33. Acidic

34. $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2\uparrow$

35. Strong alkalis are corrosive in nature. They remove the natural oil present in the skin due to which skin loses its texture.

36. $Fe(OH)_3$ and $Cu(OH)_2$

37. NaOH

38. $Cu(OH)_2$

39. A salt formed by the partial replacement of hydroxyl ions (OH^-) of a base by an anion is called basic salt. For example, $Pb(OH)NO_3$, Pb(OH)Cl, etc.

40. A salt formed by the partial replacement of the ionisable hydrogen ions of an acid by a cation is called acid salt. For example, $NaHSO_4$, $KHSO_4$, etc.

41. Formula of a normal salt: Na_3PO_4

Two acid sodium salts of phosphoric acid: NaH_2PO_4, Na_2HPO_4.

42. Citric acid

43. Bases can be called as opposite of acids because their behaviour is exactly the opposite to that of acids. For example, acids turn blue litmus red whereas bases turn red litmus blue.

44. NaCl

45. *p*H of the solution will increase.

46. Uses of

a. Boric acid: It is used in eye wash and talcum powder.

b. Acetic acid: It is used in cooking (in the form of vinegar) and food preservation.

47. Uses of

a. Aluminium hydroxide: As an antacid and as a foaming agent in the extinguishers.

b. Magnesium hydroxide: As an antacid for relief from acidity and a laxative.

48. Uses of

a. Sodium benzoate (C_6H_5COONa): As a food preservative and an antiseptic.

b. Sodium hydrogencarbonate ($NaHCO_3$): As an antacid and in fire extinguishers.

49. Red cabbage juice is an acid-base indicator. It turns red in acidic solutions, purple in neutral solutions and greenish-yellow in basic solutions. It can be prepared by the following method.

Chop the red cabbage into small pieces and place a few pieces in a container. Add some boiling water to the container and allow it to stand for 15–20 minutes. Filter the liquid. This liquid is red-cabbage juice, which will act as an indicator. Note that the colour of the juice

is purple-bluish, which is its colour in neutral solutions.

50. Indicator (phenolphthalein)

51. Alkaline

52. Hydrogen

53. Moist blue litmus paper will turn red because in the presence of water, HCl gas ionises to give $H^+(aq)$ ions which are responsible for acidic property.

54. Universal indicator

55. Higher

56. The solution that has *p*H = 2 has more H^+ ion concentration.

57. NH_4OH; $NH_4OH + HCl \longrightarrow NH_4Cl + H_2O$

58. Chlorine

59. $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$
(A)

60. Dry HCl gas does not undergo dissociation to form H^+ and Cl^- ions because HCl is a covalent molecule. This dissociation cannot occur in the absence of water. Since H^+ ion is not present in dry HCl gas, the colour of dry litmus paper does not change.

61. Dry slaked lime [$Ca(OH)_2$] on treatment with chlorine yields bleaching powder.

62. The common name of the given compound is bleaching powder.

63. Sodium carbonate (washing soda) is used for softening hard water.

B. Short Answer Type-I Questions

1. Inorganic acids undergo complete ionisation in water and hence are strong acids. Organic acids undergo ionisation only to a small extent and hence are weak acids.

2. $NaHSO_4$ is formed by the reaction of NaOH and H_2SO_4. It contains one H^+ ion given by sulphuric acid and gets dissolved in water to give hydrogen ions. Also, it can donate its H^+ ion to a strong base even though it is not an acid.

3. The bases which are soluble in water are called alkalis. So, all alkalis are bases, but all bases are not alkalis. For example, KOH (base) is an alkali since it is soluble in water, but $Cu(OH)_2$ (base) is not an alkali since it is not soluble in water.

4. *p*H is defined as the logarithm of reciprocal of hydrogen ion concentration. Higher the concentration of H^+ ions, the lower is the *p*H of a solution.

5. a. Water of crystallisation

b. White

6. a. Concentrated acid: A concentrated acid is almost pure acid with very little water.

Dilute acid: A dilute acid is an acid which contains more water and less acid.

b. Strong acids: Acids which dissociate to a large extent in a solution are called strong acids.

Weak acids: Acids which undergo ionisation to a small extent only are called weak acids.

7. When one mole of a strong acid reacts with one mole of a strong base, heat liberated is called the heat of neutralisation. Since all neutralisation reactions are accompanied by the formation of water, the energy change accompanying any neutralisation reaction of a strong acid and a strong base is same.

8. a. $HCO_3^- + H^+ \longrightarrow H_2CO_3$

b. $NH_4^+ + OH^- \longrightarrow NH_4OH$

In the above equations, HCO_3^- – base, H^+ – acid, NH_4^+ – acid, OH^- – base.

9. The acid used

a. in eye wash – boric acid

b. for removing ink spots – oxalic acid

c. in soft drinks – carbonic acid

d. in aspirin – ethanoic acid

10. a. Citric acid

b. Tartaric acid

c. Nitric acid

d. Acetic acid

11. One salt that is used in

a. dry cells – ammonium chloride

b. toothpaste – calcium carbonate

c. photography – sliver bromide

d. textile industry – bleaching powder

12. The molecular formula for:

nitric acid – HNO_3

phosphoric acid – H_3PO_4

carbonic acid – H_2CO_3

ethanoic acid – CH_3COOH

C. Short Answer Type-II Questions

1. Strong acid: Acids which dissociate to a large extent in a solution are called strong acids.

Strong acids produce a high concentration of hydrogen ions (H^+) or hydronium ions (H_3O^+) in a solution. For example, a solution of H_2SO_4 in water is a good conductor of electricity because it dissociates completely (almost 100%) in solution.

Concentrated acid: A concentrated acid is almost pure acid with very little water.

2. An aqueous solution of HCl is acidic in nature whereas an aqueous solution of ammonia is basic in nature. Also, an aqueous solution of HCl contains H^+ and Cl^- ions whereas an aqueous solution of NH_3 contains NH_4^+ and OH^- ions.

3. The term 'weak' with reference to acids and bases means that the given acid/base ionises only partially in solution. Hence, it furnishes very less number of H^+ ions (in case of acids) or OH^- ions (in case of bases). Since both acetic acid and ammonia dissociate only to a very small extent in water, they are weak acid and weak base, respectively.

4. i. The acidity of soil is reduced by adding slaked lime (calcium hydroxide) to the soil. An acidic soil is harmful for the growth of plants.

ii. Excessive hydrochloric acid produced in the stomach of a patient suffering from acidity is neutralised by giving antacid tablets containing magnesium hydroxide to the patient.

$2HCl + Mg(OH)_2 \longrightarrow MgCl_2 + 2H_2O$

iii. The stings of yellow wasps contain an alkali which is neutralised by rubbing with vinegar (dilute solution of acetic acid).

5. The soil is acidic. So, the farmer decided to make it of desired *p*H by adding lime which is basic in nature.

6. The acidity of a solution is expressed in terms of a parameter called *p*H, where *p*H stands for hydrogen *potenz* (hydrogen power). The scale indicating the hydrogen ion concentration of solutions in terms of *p*H values is called *p*H scale.

7. In a soda-acid fire extinguisher, the reaction of a metal hydrogen carbonate (e.g. $NaHCO_3$) or Na_2CO_3 with an acid (e.g. H_2SO_4) is used to produce carbon dioxide gas which forms an effervescence. Carbon dioxide being heavier than air and a non-supporter of combustion, cuts off the supply of air and as a result, the fire gets extinguished.

$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + 2CO_2$

8. a. Two bases which are not alkalis: $Cu(OH)_2$ and $Al(OH)_3$

b. A normal salt and an acid salt of the same acid: Na_2SO_4 and $NaHSO_4$

c. $PbCl_2$

9. a. An alkali

b. Precipitate

c. Weak acid

10. a. $Cu(NO_3)_2 + H_2SO_4 \longrightarrow CuSO_4 + 2HNO_3$

b. $2FeCl_3 + 3H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + 6HCl$

c. $3Ca(HCO_3)_2 + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 6H_2O + 6CO_2$

11. Strong acid: $HClO_4$

Strong base: NaOH

Weak base: $Mg(OH)_2$ and NH_4OH

Weak acid: HCN and CH_3COOH

12. According to the Arrhenius concept of acids and bases, acids dissociate in water to give hydrogen ions (H^+) and bases dissociate in water to give hydroxyl ions (OH^-).

HNO_3 is a strong acid because it dissociates to give more H^+ ions in water, i.e. it dissociates to a large extent. H_2CO_3 is a weak acid because it dissociates to give few H^+ ions in water, i.e. it dissociates to a small extent.

NaOH is a strong base because it dissociates in water to give more OH^- ions. NH_4OH is a weak base because it dissociates in water to give less OH^- ions.

13. Copper vessels get tarnished due to the formation of thin layer of copper oxide. The shine can be regained by rubbing the utensils with pieces of lemon. The first reaction is oxidation reaction whereas the second reaction is neutralisation reaction.

14. The nitrogeneous fertilisers such as ammonium sulphate undergo hydrolysis under the acidic condition of the soil to form sulphuric acid and ammonium hydroxide. As a result, the acidity of soil and water above soil increases. Both sulphuric acid and ammonium hydroxide are not desirable for water. Thus, pollution in water increases.

15. $NaOH + CO_2 \xrightarrow{\text{Heat}} NaHCO_3$

$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + H_2O + CO_2$

16. In the neutralisation of oxide or hydroxide, salt and water are formed while in the neutralisation of carbonate, CO_2 gas is formed in addition to salt and water.

17. Naturally occurring substances that indicate the acid-base character of substances are called natural indicators. For example, turmeric, red cabbage juice, curry powder, etc.

18. We know that acids are sour in taste while bases are bitter. Without tasting, it can be determined whether a given substance is acidic or basic in nature with the help of indicators. We can use any indicator such as phenolphthalein, methyl orange, litmus paper, etc. Let us take the example of phenolphthalein. Add two drops of phenolphthalein to a small volume (10–15 mL) of each sample. The samples which will remain colourless will be acidic while those which will change to pink colour will be basic.

19. i. Plants and animals are *p*H sensitive. Living organisms can survive only in narrow range of *p*H change.

ii. *p*H of the soil: Plants require a specific *p*H range for their healthy growth.

iii. *p*H in our digestive system: Our stomach produces hydrochloric acid that helps in the digestion of food. During indigestion the stomach produces too much acid that causes pain and irritation.

20. Washing soda is prepared from sodium carbonate by recrystallisation.

$Na_2CO_3 + 10H_2O \longrightarrow Na_2CO_3 \cdot 10H_2O$

Washing soda is a basic salt. It is used to remove the permanent hardness of water.

21. a. Sodium bicarbonate/sodium hydrogen-carbonate/baking soda and its formula is $NaHCO_3$.

b. $2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + CO_2 + H_2O$

c. It is used in fire extinguisher and for baking.

22. a. Add 10 mL of concentrated sulphuric acid slowly to 90 mL of water with constant stirring.

Dilution of acid is a highly exothermic process. If water is added to concentrated sulphuric acid, heat generated causes the mixture to splash, leading to burns and the glass container can even break.

b. On dilution, the concentration of H_3O^+ ions decreases per unit volume.

23. NaCl is obtained by reacting an acid and a base. The acid is HCl and the base is NaOH.

$HCl + NaOH \longrightarrow NaCl + H_2O$

NaCl (ionic compound) is an important normal salt and is known as common salt. It occurs in nature as large brown crystals due to the presence of various impurities. This natural brown salt is known as rock salt. It occurs as beds under the earth and is mined similarly as coal. It is believed that the beds of rock salt were formed due to the drying of seas in prehistoric times. The main source of sodium chloride is sea water.

24. The acid and base that form sodium hydrogen carbonate are H_2CO_3 (acid) and NaOH (base).

$NaOH + H_2CO_3 \longrightarrow NaHCO_3 + H_2O$

$NaHCO_3$ is basic in nature and its *p*H value will be around 8.

25. a. It is a decomposition reaction and gas X is nitrogen dioxide.

b. $2Cu(NO_3)_2(s) \xrightarrow{\text{Heat}} 2CuO(s) + 4NO_2(g) + O_2(g)$

c. *p*H range of aqueous and solution of the gas X (NO_2) is between 0 and 7, i.e. acidic.

26. a. The dilution of acid is an exothermic reaction, so on adding acid to water the heat that evolves gets absorbed by the water but if water is added to acid, a large amount of heat is evolved leading to a spill of acid which may cause severe burns.

b. Dry HCl gas does not change the colour of a dry litmus paper because dry HCl gas does not undergo dissociation to form ions as there is an absence of an aqueous medium. The colour of the litmus paper changes only when the ions are formed.

27. Sodium chloride (NaCl) is used to prepare sodium hydroxide (NaOH) in industries. This process is called chlor-alkali process.

$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$

Gas X is Cl_2.

$Ca(OH)_2 + \underset{\text{(Gas X)}}{Cl_2} \longrightarrow \underset{\text{(Y)}}{CaOCl_2} + H_2O$

So, X is Cl_2 and Y is $CaOCl_2$ (bleaching powder).

28. The compounds which show the properties of both acid as well as base are called amphoteric oxides. Amphoteric oxides react both with acids and bases to form salt and water. For example, ZnO (zinc oxide)

In acid: $ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$

In base: $ZnO + 2NaOH + H_2O \longrightarrow Na_2[Zn(OH)_4]$

29. The concentration of H^+ (*aq*) ions determines the acidic nature of the solution. Hence, when the

concentration of hydrogen (H^+) ions increases the solution becomes more acidic while when the hydrogen (H^+) ion concentration decreases there will be an increase in the basicity of the solution. Yes, basic solutions also have H^+ (*aq*) ions but they are basic because the concentration of hydroxide (OH^-) ions is more as compared to H^+ ions concentration.

30. Base B is sodium hydroxide (NaOH). Dry pellets of sodium hydroxide (NaOH) absorb moisture from the atmosphere and become sticky. It is also a by-product of chlor-alkali process.

Neutralisation reaction occurs when B (NaOH) is treated with an acidic oxide.

$2NaOH + SO_2 \longrightarrow Na_2SO_3 + H_2O$

31. The chemical formula of washing soda is $Na_2CO_3 \cdot 10H_2O$.

Washing soda can be obtained by heating baking soda. On heating, baking soda gives carbonate, carbon dioxide and water. Consequently, the recrystallisation of sodium carbonate gives washing soda. The chemical equations involved in the process are:

$$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + CO_2 + H_2O$$

$$\underset{\text{Sodium carbonate}}{Na_2CO_3} + 10H_2O \xrightarrow{\text{Recrystallisation}} \underset{\text{Washing soda}}{Na_2CO_3 \cdot 10H_2O}$$

Washing soda is used in glass and paper industries.

32. a. The name of the white powder is plaster of Paris. Its chemical formula is $CaSO_4 \cdot \frac{1}{2} H_2O$.

b. Plaster of Paris can be prepared by the heating process of gypsum.

c. The chemical reaction between plaster of Paris and water is given below:

$$CaSO_4 \cdot \frac{1}{2} H_2O + 1\frac{1}{2} H_2O \longrightarrow \underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O}$$

d. Plaster of Paris is also used in several construction works and for making pottery items.

33. Baking soda which is a salt is used in bakery products which gives sodium carbonate and carbon dioxide gas on heating.

$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + CO_2 + H_2O$

So, salt P is sodium bicarbonate and salt Q is sodium carbonate which is used to remove the hardness of water. Gas R is carbon dioxide gas which turns lime water milky.

34. The white powder added while baking cakes to make them soft and spongy is baking powder. It consists of sodium bicarbonate ($NaHCO_3$) and edible acids such as tartaric acid.

On heating, baking powder gives CO_2 which makes the cake to rise up and hence, it becomes soft and spongy.

Also, tartaric acid neutralises the bitterness of sodium bicarbonate.

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

35. The by-products of chlor-alkali process are sodium hydroxide, chlorine and hydrogen gas. When chlorine gas reacts with lime water, it produces bleaching powder which is utilised as a bleaching agent in the chemical industry.

$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$

$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$

Gas A is Cl_2 and compound B is bleaching powder

36. The name of the compound is plaster of Paris and its chemical formula is $CaSO_4 \cdot \frac{1}{2} H_2O$. It can be prepared by heating gypsum.

$CaSO_4 \cdot 2H_2O \xrightarrow{\Delta} CaSO_4 \cdot \frac{1}{2} H_2O + 1\frac{1}{2} H_2O$

It is used in the hospitals mainly for supporting fractured bones in the right position.

37. Plaster of Paris (POP) is used for plastering of fractured bones.

Preparation of POP:

$$CaSO_4 \cdot 2H_2O \xrightarrow{-373K} CaSO_4 \cdot \frac{1}{2} H_2O + 1\frac{1}{2} H_2O$$

Precaution for the preparation of plaster of Paris:

Gypsum should not be heated above 373 K otherwise it will form $CaSO_4$.

38. When sodium hydroxide is heated with zinc granules, sodium zincate is formed and hydrogen gas is evolved.

$2NaOH(aq) + Zn(s) \longrightarrow Na_2ZnO_2(aq) + H_2(g)$

When burning splinter is brought near the mouth of the test tube, it burns with a pop sound.

If zinc granules react with dilute solution of strong acids (HCl or H_2SO_4) then again hydrogen gas will be evolved.

$Zn(s) + 2HCl\ (dil.) \longrightarrow ZnCl_2 + H_2\uparrow$

$Zn(s) + H_2SO_4\ (dil.) \longrightarrow ZnSO_4 + H_2\uparrow$

39. The salt used to make tasty and crispy *pakoras* is baking soda, i.e. sodium bicarbonate ($NaHCO_3$).

The chemical equation for the formation of $NaHCO_3$ is given below:

$NaCl + NH_3 + H_2O + CO_2 \longrightarrow NaHCO_3 + NH_4Cl$

Uses of baking soda:

1. It is used as an antacid as it reduces the acidity in the stomach.
2. It is used in soda-acid fire extinguishers.

40. In chlor-alkali process, when electricity is passed through an aqueous solution of sodium chloride (brine), it decomposes to form sodium hydroxide, and chlorine and hydrogen gases are liberated.

Use of sodium hydroxide:

- For degreasing metals and for making paper and artificial fibres.

Use of chlorine gas:

- In the production of bleaching powder and in the manufacture of pesticides.

Use of hydrogen gas:

- In the hydrogenation of oils and used as a fuel.

41. Hydrogen gas is usually liberated when an acid reacts with a metal. For example, when dilute HCl is added to a small piece of clean magnesium ribbon, it results in the formation of magnesium chloride and hydrogen gas.

$Mg + 2HCl \longrightarrow MgCl_2 + H_2$

Hydrogen gas burns with a pop sound. So, when a burning splinter is brought close to the mouth of a test tube containing hydrogen gas, it burns with a pop sound.

42. The fixed number of water molecules which remain in the crystal lattice of crystalline salts are called water of crystallisation.

The chemical formula of copper sulphate is $CuSO_4 \cdot 5H_2O$, suggesting that it is a hydrated salt in which five molecules of water are attached to each formula unit of $CuSO_4$. This salt is blue in colour. When heated, it becomes white in colour. This is because it loses its water molecules to form anhydrous $CuSO_4$. This shows that crystals of copper sulphate contain water of crystallisation.

43. When chlorine is passed over slaked lime at 313 K, it forms bleaching powder. The equation for the reaction is as follows:

$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$

The uses of bleaching powder are:

i. It is used for bleaching cotton fibre and cotton fabrics in textile industry.

ii. It is used for disinfecting drinking water.

44. The gas evolved would be carbon dioxide, which would make lime water milky. This is because marble is chemically calcium carbonate. On reacting with HCl, it would form $CaCl_2$, H_2O and CO_2. CO_2 turns lime water milky due to the formation of $CaCO_3$.

The chemical equations for the reactions are as follows:

a. $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

b. $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

D. Long Answer Type Questions

1. a. $NaOH(aq) + CO_2(g, \text{excess}) \xrightarrow{\text{evaporate}} NaHCO_3(s)$

$2NaHCO_3(s) \xrightarrow{\text{Heat}} Na_2CO_3(s) + H_2O(g) + CO_2(g)$

b. $NaOH(aq) + CO_2(g, \text{excess}) \xrightarrow{\text{evaporate}} NaHCO_3(s)$

2. According to Arrhenius, an acid is a substance that produces hydrogen ions in water and a base is a substance that produces hydroxyl ions in water. In aqueous solution, hydrogen ion combines with a molecule of water to form hydronium ion. For example,

$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$

$NaOH \rightleftharpoons Na^+ + OH^-$

According to the Arrhenius concept, acid-base neutralisation involves the reaction between $H^+(aq)$ and $OH^-(aq)$ ions to form a water molecule.

$H^+(aq) + OH^-(aq) \rightleftharpoons H_2O(l)$

The above equation may also be represented as:

$H_3O^+(aq) + OH^-(aq) \rightleftharpoons 2H_2O(l)$

3. a. **Weak acid:** acetic acid, phosphoric acid and carbonic acid.

b. **Strong acid:** hydrochloric acid, nitric acid and sulphuric acid.

c. **Weak base:** ammonium hydroxide, copper hydroxide and ferrous hydroxide.

d. **Strong base:** sodium hydroxide, potassium hydroxide and calcium hydroxide.

4. a. Neutralisation

b. Amphoteric substance

c. Ammonia

d. Lactic acid

e. Carbonic acid

5. a. Uses of three different acids are as follows:

i. **Hydrochloric acid:** It is used as a toilet cleaner, in swimming pools, etc. It also

plays a key role in digestion of food and killing of bacteria in the stomach.

ii. **Boric acid:** It is used in eye wash, talcum powder, dusting powder, etc.

iii. **Tartaric acid:** It is used in baking powder.

b. Uses of three different bases are as follows:

i. **Sodium hydroxide:** It is used in the manufacture of soap and synthetic fibres (e.g. rayon), as oven cleaner, in paper industry, etc.

ii. **Potassium hydroxide:** It is used in drain cleaner, in nickel-iron storage battery, in manufacture of toilet soap, for absorbing CO_2 gas, etc.

iii. **Ammonium hydroxide:** It is used as a grease stain remover, for dry cleaning, for household cleaning, etc.

c. Uses of three different salts are as follows:

i. **Aluminium chloride:** It is used in the manufacturing of detergents, as a catalyst in organic reactions, etc.

ii. **Ammonium chloride:** It is used in dry cells, as a fertiliser, etc.

iii. **Calcium carbonate:** It is used as a building material (marble), in tooth powder, in paints, etc.

6.

Acid	Base
Turns blue litmus red.	Turns red litmus blue.
Sour in taste.	Bitter in taste.
Releases H^+ ions in water.	Releases OH^- ions in water.
*p*H is less than 7.	*p*H is more than 7.
Example: HCl, H_2SO_4, etc.	Example: NaOH, NH_4OH, etc.

Neutralisation is a type of chemical reaction in which an acid and a base react to form salt and water.

a. When neutralisation of a strong acid with a weak base takes place, it leads to the formation of acidic salt. For example,

$HCl + NH_4OH \longrightarrow NH_4Cl + H_2O$

b. When neutralisation of a weak acid with a strong base takes place, it leads to the formation of basic salt. For example,

$NaOH + CH_3COOH \longrightarrow CH_3COONa + H_2O$

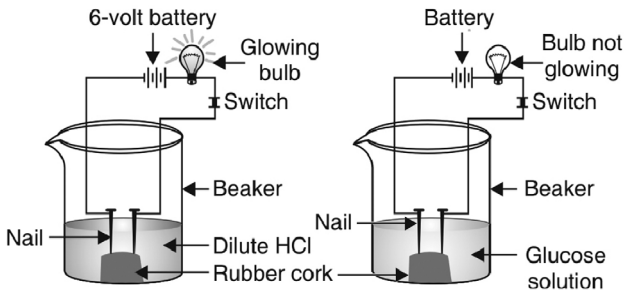
c. When neutralisation of a strong acid with a strong base takes place, it leads to the formation of neutral salt. For example,

$NaOH + HCl \longrightarrow NaCl + H_2O$

7. Two nails are fitted on a cork and are kept in a 100 mL beaker. The nails are then connected to the two terminals of a 6-volt battery through a bulb and a switch. Some dilute HCl is poured in the beaker and the current is switched on. The same experiment is then performed with glucose solution as well as with alcohol solution.

Observations:

It will be observed that the bulb glows in the HCl solution and does not glow in the glucose and alcohol solutions.



Result:

HCl dissociates into H^+ and Cl^- ions. These ions conduct electricity in solution resulting in the glowing of the bulb. On the other hand, glucose and alcohol solutions do not dissociate into ions. Therefore, they do not conduct electricity.

Conclusion:

From this activity, it can be concluded that all acids contain hydrogen but not all compounds containing hydrogen are acids. That is why, though alcohols and glucose contain hydrogen, they are not categorised as acids.

8. Four test tubes are taken and labelled as A, B,C and D. The test tubes are kept in a stand. Four pieces of zinc are taken in each test tube. 2 mL each of dil. HCl, dil. H_2SO_4, dil. HNO_3 and dil. H_2CO_3 are added in the test tubes separately. A lighted matchstick is brought in contact with the evolved gas. The lighted matchstick extinguishes and the gas burns with a popping sound. The evolved gas is hydrogen coming from each acid. Hence, it shows that all acids contain hydrogen ion (H^+) in common. Thus, hydrogen is responsible for the acidic character of acids.

9. Take 2 mL of dilute HCl in a test tube and add 2 drops of phenolphthalein to it. The solution remains colourless because phenolphthalein does not show any colour in acidic solutions. Now, add a base, i.e. dilute NaOH solution drop by drop to the test tube. When a light permanent pink colour appears in the test tube, it is that point

where neutralisation just takes place completely. In alkaline solutions, phenolphthalein turns pink.

10. i. A *p*H range is essential for the survival of plants and animals. Living organisms can survive only in a narrow *p*H range, for example, our body works within the *p*H range of 7.0 – 7.8. Acid rain with *p*H less than 5.6 affects plants as well as the aquatic life.

ii. Digestion of food in our stomach takes place in the presence of HCl. When there is excess of acid in the stomach, it will lead to pain and irritation. This can be prevented by taking antacids [$Mg(OH)_2$ or milk of magnesia] which can neutralise the excess acid.

iii. When the *p*H of mouth is lower than 5.5 due to the production of acids by bacterial degradation of sugar and food particles, tooth decay starts. This can be prevented by using the toothpaste which is generally basic for cleaning the teeth.

iv. Plants grow best when *p*H of the soil is close to 7. Soils having *p*H values in the alkaline region or highly acidic region are not favourable for the growth of plants. Hence, if the soil is too acidic, it is treated with quick lime/slaked lime. In case of soils with *p*H values in the alkaline region, the top soil is replaced by soil with *p*H value in the less acidic region.

v. Bee-sting leaves an acid which causes pain and irritation. Using a mild base like baking soda on the affected area gives relief. When our body comes in contact with nettle leaves, the hair sting on our skin and we get burning pain due to the injection of methanoic acid by the hair. This can also be relieved by rubbing the affected area with baking soda.

11. a. Copper chloride – $CuCl_2$

b. Sodium sulphate – Na_2SO_4

c. Calcium carbonate – $CaCO_3$

d. Sodium nitrate – $NaNO_3$

e. Copper (II) sulphate – $CuSO_4$

12. a. Baking powder is a mixture of baking soda and a mild edible acid such as tartaric acid. When baking powder is heated it gives out carbon dioxide which makes the bread or cake to rise up, making them soft and spongy.

b. Baking soda on reaction with an acid, such as sulphuric acid, produces carbon dioxide which being heavier than air and a non-supporter of combustion, cuts off the supply of air. As a result, the fire gets extinguished. This is why it is also used in soda-acid fire extinguishers.

$$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + 2CO_2$$

c. The *p*H value of baking soda solution is higher than 7.

13. a. The formula of plaster of Paris is written as $CaSO_4 \cdot \frac{1}{2} H_2O$. It is written in this form because two formula units of $CaSO_4$ share one molecule of water.

b. Sodium hydrogen carbonate is a mild base. Being alkaline, it neutralises excess acid in the stomach and gives relief. This is why, it is an essential ingredient in most antacids.

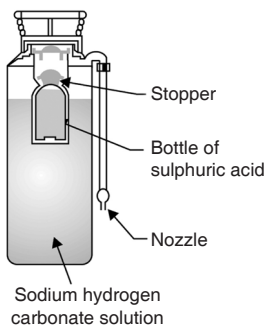
c. The process is called the chlor-alkali process because of the products formed. Chlor for chlorine and alkali for sodium hydroxide.

E. Source-based / Case-based / Passage-based / Integrated Assessment Questions CBQ

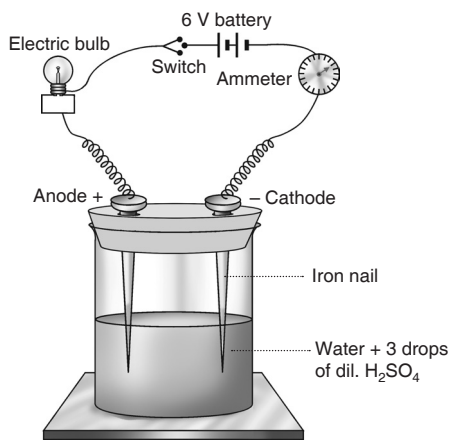
1.	**a.** iii.	**b.** iii.	**c.** ii.	**d.** i.	**e.** iii.
2.	**a.** ii.	**b.** iii.	**c.** iii.	**d.** ii.	**e.** i.
3.	**a.** ii.	**b.** i.	**c.** iv.	**d.** ii.	**e.** ii.
4.	**a.** ii.	**b.** iii.	**c.** i.	**d.** iv.	**e.** iii.
5.	**a.** iv.	**b.** i.	**c.** iv.	**d.** iii.	**e.** ii.

F. Diagrammatic Questions

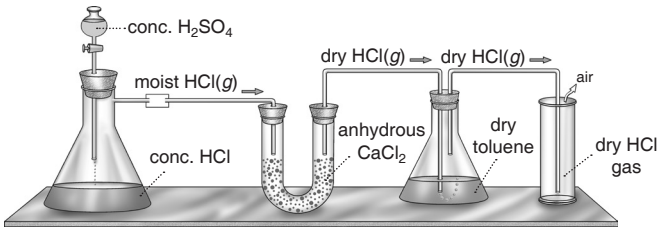
1. Soda-acid fire extinguisher:



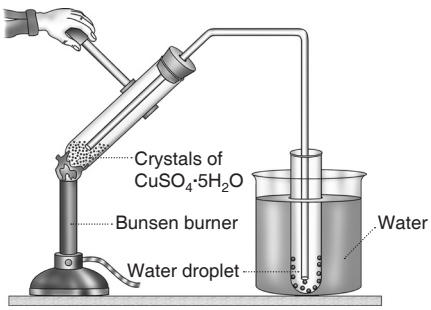
2. Electrical conduction of acid solution in water:



3. Preparation of anhydrous HCl gas:



4. Removal of water of crystallisation from $CuSO_4 \cdot 5H_2O$:



Refer Activity 28 from page 88 of the textbook.

G. Higher Order Thinking Skills (HOTS) Questions

1. The solution is of a base.

2. The mixing of an acid with water is an exothermic reaction. When an acid (conc. H_2SO_4 or conc. HNO_3) is mixed with water, a large amount of heat is evolved and as a result the splashing of water occurs and the glass container may break due to excessive localised heating. Hence, while diluting concentrated acid, it is recommended that acid should be added to water in small lots and not water to the acid.

$H_2SO_4\ (l) + 2H_2O\ (l) \longrightarrow 2H_3O^+(aq) + SO_4^{2-}(aq) + \text{Heat}$

3. The metal is copper.

The reaction involved is:

$Cu_2O + 2HCl \longrightarrow CuCl_2 + H_2O$

4. b. When dilute hydrochloric acid is used as the electrolyte, the electric blub glows due to the dissociation of aqueous HCl.

5. Acid A is formic acid and base B is sodium bicarbonate.

6. Acidic.

7. Solution A has more H^+ ion concentration. Solution A is acidic and Solution B is basic.

8. $2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$

9. The tooth decay can be prevented by cleaning the mouth, avoiding eating sweet-tasting foods and brushing the teeth, preferably using a fluoride toothpaste. Our saliva being slightly alkaline in nature (*p*H = 7.5) neutralises only a small fraction of acid and major part of the acid still remains in our mouth. Toothpastes are slightly alkaline in nature and neutralise the acid. In the fluoride toothpastes, sodium fluoride is added in order to prevent tooth decay. Sodium fluoride reacts with calcium phosphate present in our teeth to form insoluble calcium fluoride which gets coated on our teeth preventing tooth decay.

10. Antacids are bases which are used to relieve the pain and discomfort caused due to acidity, a condition in which the stomach produces too much acid. Being basic in nature, antacids neutralise the excess acid.

11. We are given that the solution in test tube turned pink on addition of phenolphthalein. This means that solution A is basic in nature. When dilute HCl was added, the pink colour disappeared because HCl neutralised the base. When solution A was added to the test tube, the solution in test tube became alkaline again because of which the pink colour reappeared.

12. Compound A is sodium carbonate and gas B is carbon dioxide. Reaction of compound A with dilute HCl is as follows:

$Na_2CO_3 + 2HCl \longrightarrow NaCl + H_2O + CO_2$

When CO_2 is passed through lime water, lime water turns milky due to the formation of $CaCO_3$. The equation for the reaction is as follows:

$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

When excess of CO_2 is passed through this solution, it turns colourless due to the formation of soluble calcium bicarbonate.

$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$

13. Preparation of bleaching powder:

$Ca(OH)_2(s) + Cl_2(g) \longrightarrow CaOCl_2(s) + H_2O(l)$

14. A – sodium chloride (NaCl), B – sodium hydroxide (NaOH), C – chlorine gas (Cl_2), D – hydrogen gas (H_2)

15. Pop sound will be observed in both the test tubes, but since evolution of hydrogen gas is more vigorous in case of test tube A, the sound will be more in case of test tube A.

16. a. Solution A with *p*H = 5

b. Solution E with *p*H = 9

c. Solution D with *p*H = 7

d. Solution C with *p*H = 12

e. Solution B with *p*H = 1

17. The pain in the muscles and stiffness of muscles after strenuous exercise are due to the accumulation of metabolic waste such as lactic acid in the muscles. During such strenuous exercise, the oxygen supply to the muscles is unable to keep pace with the rate of aerobic metabolism for release of energy and the muscle cells switch over to anaerobic metabolism for release of energy, which causes accumulation of lactic acid in the muscles.

H. Value-Based Questions (Optional)

1. a. Sodium chloride occurs in nature as large brown crystals due to the presence of various impurities. This natural brown salt is known as rock salt. It occurs as beds under the earth, which are believed to be formed due to the drying of seas in prehistoric times.

b. The main source of sodium chloride is sea water. It is prepared by evaporation of sea water followed by fractional crystallisation when it is separated from impurities such as KCl, $MgCl_2$, $MgSO_4$, etc.

c. Common salt containing a small amount of potassium iodide is known as iodised salt. The concentration of potassium iodide in common salt is about 15 ppm.

d. Common salt is used for cooking food, in the preparation of salads, pickles, freezing mixture, etc. It is also used

i. in the manufacture of soap.

ii. for making glazed pottery.

e. Sodium hydroxide is prepared by the chlor-alkali process. When electricity is passed through an aqueous solution of sodium chloride, called brine, it decomposes to form sodium hydroxide. Chlorine and hydrogen are also obtained in the process.

$$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$

f. To prepare sodium bicarbonate, ammonia is bubbled through an aqueous solution of sodium chloride (called brine) to produce ammoniacal brine. Carbon dioxide is then passed through ammoniacal brine to form $NaHCO_3$ and NH_4Cl. $NaHCO_3$ being sparingly soluble in water precipitates out from the solution. $NaHCO_3$ is filtered off and dried. The filterate containing NH_4Cl is used to regenerate NH_3.

$$NaCl(aq) + NH_3(g) + H_2O(l) + CO_2(g) \longrightarrow NaHCO_3(s) + NH_4Cl(aq)$$

g. By doing the Dandi March, Mahatma Gandhi displayed the qualities of courage, truthfulness and devotion to his motherland and the people.

2. a. Carbohydrates and sweet-tasting food particles which remain in our mouth after eating are degraded by bacteria to produce acids. These acids corrode the tooth enamel, which results in cavities and bad odour in our mouth.

b. Cavities are formed when the *p*H of the mouth falls below 5.5. The carbohydrate and food particles which remain in our mouth after eating are degraded by bacteria to produce acids. These acids corrode the enamel, and in the long run, we get cavities.

c. Tooth decay can be prevented by cleaning the mouth after eating, avoiding eating sweet-tasting foods and brushing the teeth two times, preferably using a fluoride toothpaste.

d. The student displayed care for his younger brother and also scientific awareness.

P. 108 TEST PAPER

1. a. HCl

b. CH_3COOH

2. a. Boric acid – non-volatile acid

b. Carbonic acid – volatile acid

3. a. $KHCO_3$– acidic salt

b. Na_3PO_4– normal salt

c. $PbCO_3 \cdot Pb(OH)_2$– basic salt

4. a. When an aqueous solution of sodium hydrogen carbonate is heated, it decomposes to form sodium carbonate, carbon dioxide and water.

$$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + H_2O + CO_2$$

b. When chlorine is passed through slaked lime, bleaching powder is formed.

$$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$$

5. a. Acid salt: A salt formed by the partial replacement of the ionisable hydrogen ion of an acid by a cation is called acid salt. For example, $NaHCO_3$, $KHCO_3$, etc.

b. Neutralisation: The reaction between an acid and a base to produce salt and water is known as a neutralisation reaction.

c. *p*H: The parameter used for expressing the acidity of a solution is known as *p*H. '*p*' in

*p*H stands for *potenz* in German, and means hydrogen power. The quantity *p*H is defined as the logarithm of the reciprocal of the hydrogen ion concentration $[H^+]$.

$$pH = -\log [H^+]$$

d. Indicator: An indicator is a substance which helps in determining whether a given substance is acidic or basic in nature by exhibiting characteristic colours in acidic and basic medium.

6. a. $Mg(HCO_3)_2 + 2HNO_3 \longrightarrow Mg(NO_3)_2 + 2CO_2 + 2H_2O$

b. $3NaHCO_3 + H_3PO_4 \longrightarrow Na_3PO_4 + 3CO_2 + 3H_2O$

c. $Ca(HCO_3)_2 + H_2SO_4 \longrightarrow CaSO_4 + 2H_2O + 2CO_2$

d. $K_2CO_3 + 2HNO_3 \longrightarrow 2KNO_3 + H_2O + CO_2$

7. Plaster of Paris can be prepared by heating gypsum at 373 K. The equation for the reaction is as follows:

$$CaSO_4 \cdot 2H_2O \xrightarrow{\text{Heat}} CaSO_4 \cdot \frac{1}{2} H_2O + 1\frac{1}{2} H_2O$$

P. 108 EQUATIONS WORKSHEET

PREPARATION OF SALTS

1. Direct combination of elements:

a. $Fe + Cl_2 \longrightarrow FeCl_2$

b. $Hg + S \longrightarrow HgS$

2. Action of dilute acids on metals:

a. $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$

b. $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$

c. $Cu + H_2SO_4 \longrightarrow$ No reaction

3. Action of dilute acids on metal carbonates:

a. $Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$

b. $CuCO_3 + H_2SO_4 \longrightarrow CuSO_4 + H_2O + CO_2$

c. $PbCO_3 + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O + CO_2$

4. Action of dilute acids on metal hydrogen carbonates:

a. $Ca(HCO_3)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O + 2CO_2$

b. $3NaHCO_3 + H_3PO_4 \longrightarrow Na_3PO_4 + 3CO_2 + 3H_2O$

c. $2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + 2CO_2$

5. Reaction of acids and bases:

a. $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$

b. $Cu(OH)_2 + 2HCl \longrightarrow CuCl_2 + 2H_2O$

c. $Pb(OH)_2 + 2HNO_3 \longrightarrow Pb(NO_3)_2 + 2H_2O$

6. Treating alkalis with acidic oxides

a. $2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

b. $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

ACIDS

1. Definition (produces hydronium ions on dissolution in water)

a. Hydrochloric acid

$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

b. Sulphuric acid

$H_2SO_4 + 2H_2O \longrightarrow 2H_3O^+ + SO_4^{2-}$

c. Nitric acid

$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$

d. Phosphoric acid

$H_3PO_4 + 3H_2O \longrightarrow 3H_3O^+ + PO_4^{3-}$

2. Properties of acids

a. Action with carbonates and hydrogen-carbonates:

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$

$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$

$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + 2CO_2$

b. Action with bases (neutralisation)

$NaOH + HCl \longrightarrow NaCl + H_2O$

$CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$

$PbO + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$

c. Action with salts

$2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$

$2NaNO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2HNO_3$

$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

d. Action with metals

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

$Mg + 2HCl \longrightarrow MgCl_2 + H_2$

BASES/ALKALIS

1. Definition (produces hydroxyl ions on dissolution in water)

$NaOH \longrightarrow Na^{+} + OH^{-}$

$Ca(OH)_2 \longrightarrow Ca^{2+} + 2(OH)^{-}$

$Al(OH)_3 \longrightarrow Al^{3+} + 3(OH)^{-}$

2. Properties of bases

a. Action of heat:

$Ca(OH)_2 \longrightarrow Ca^{2+}(aq) + 2OH^{-}$

b. Action with metallic salts:

$AlCl_3 + 3NaOH \longrightarrow Al(OH)_3 + 3NaCl$

$ZnCl_2 + 2NaOH \longrightarrow Zn(OH)_2 + 2NaCl$

$FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 + 3NaCl$

c. Action with acids (neutralisation):

$NaOH + HCl \longrightarrow NaCl + H_2O$

$Ca(OH)_2 + H_2SO_4 \longrightarrow CaSO_4 + 2H_2O$

$2Al(OH)_3 + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 6H_2O$

d. Action with metals:

$Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$

$2Al + 6NaOH \longrightarrow 2Na_3AlO_3 + 3H_2$

CHAPTER – 3

METALS AND NON–METALS

P. 118–119 Check Your Progress 1

1. Si, Ge, As and Sb are four semi-conducting elements.

2. There are seven elements such as B, Si, Ge, As, Sb, Po and Te which exhibit the property of metals as well as non-metals, and these elements are called **semi-metals**.

3. a. Mercury **b.** Silver **c.** Gallium **d.** Mercury **e.** Osmium **f.** Lithium

4. a. 20 **b.** 7 **c.** high **d.** 6.2×10^3 **e.** malleable **f.** ductile **g.** amalgam **h.** photoelectric effect **i.** stainless steel

5. a. F **b.** F **c.** T **d.** F **e.** T **f.** T **g.** F

P. 129 Check Your Progress 2

1. K > Na > Cu > Ag

2. Ca and Mg

3. a. less **b.** more **c.** zinc **d.** copper

4. a. F **b.** F **c.** F **d.** F **e.** T **f.** T

P. 136 Check Your Progress 3

1. Metal – potassium

Non-metals – helium, phosphorus, boron and graphite

2. a. Bromine **b.** Graphite **c.** Iodine **d.** Diamond

3. Neutral oxides – H_2O, CO, NO

Acidic oxide – CO_2

Basic oxides – CaO, K_2O

4. a. acidic, neutral **b.** covalent **c.** covalent **d.** low

5. a. F **b.** T **c.** T **d.** F (Diamond is also lustrous.)

6. a. and **c.**

P. 146 Check Your Progress 4

1. This is a sulphide ore and it will be concentrated with froth floatation process.

2. a. Froth floatation and magnetic separation

b. Fe and Cr

c. Aluminium and sodium

d. Copper and aluminium

3. By reduction of metal oxide.

4. a. mineral, metal **b.** chemical **c.** sulphide **d.** electrorefining **e.** lavigation

5. a. F **b.** F **c.** T **d.** T **e.** T

P. 152 Exercises

A. Objective Type Questions

I. Choose the most appropriate answer.

1. c	**2.** c	**3.** d	**4.** a	**5.** d
6. b	**7.** c	**8.** d	**9.** d	**10.** a
11. b	**12.** d	**13.** d	**14.** c	**15.** b
16. d	**17.** a	**18.** a	**19.** a	**20.** a
21. d	**22.** d	**23.** d	**24.** a	**25.** c
26. c	**27.** a	**28.** c	**29.** c	**30.** a
31. d	**32.** a			

II. Write True or False.

1. F	**2.** F	**3.** T	**4.** F	**5.** T
6. F	**7.** T	**8.** T	**9.** F	**10.** F
11. F	**12.** T			

III. Fill in the blanks.

1. Li, Os	**2.** W, Hg
3. basic, amphoteric	**4.** gangue
5. less	**6.** Al
7. Al	**8.** 1 part aluminium powder and 3 parts Fe_2O_3
9. electrolytic	**10.** impure
11. presence	**12.** duralumin
13. bauxite	**14.** pine oil
15. oxide	**16.** redox
17. aqua regia	**18.** galvanisation

IV. Match the items in column A with the items in column B.

1. b	**2.** a	**3.** d	**4.** e	**5.** c

V. Balance the following unbalanced equations.

1. $P_4O_{10} + 12NaOH \longrightarrow 4Na_3PO_4 + 6H_2O$

2. $Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$

3. $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

4. $2Cu_2S + 5O_2 + H_2O \longrightarrow 2CuSO_4 + 2CuO + H_2O$

5. $2HgS + 3O_2 \longrightarrow 2HgO + 2SO_2$

6. $2AgNO_3 + Cu \longrightarrow Cu(NO_3)_2 + 2Ag$

VI. Assertion – Reasoning Type Questions CBQ

1. a	**2.** a	**3.** c	**4.** a	**5.** c
6. a	**7.** d	**8.** b	**9.** c	**10.** a

VII. Very Short Answer Type Questions

1. Tungsten has the highest boiling point and mercury has the lowest boiling point.

2. Most malleable metal is gold and the most ductile metal is silver.

3. Brass – Cu: 60–80%, Zn: 20–40%

Bronze – Cu: 80%, Zn: 10%, Sn: 10%

4. Copper and silver

5. The general reaction of metals with water is written as:

Metal + Water $\longrightarrow$ Metal oxide + Hydrogen

Thus, when a metal reacts with water, it gains oxygen from water and water loses hydrogen. Thus, one species is oxidised and the other is reduced. This is why reactions of metals with water are redox reactions.

6. Metals react with hydrogen to form hydrides. In these reactions, the metal loses electron(s), hence, it is oxidised. On the other hand, hydrogen gains an electron, hence it is reduced. Thus, one species is oxidised and one is reduced. This is why reaction of a metal with hydrogen is a redox reaction.

7. Aqua regia is a mixture of concentrated nitric acid and hydrochloric acid in the ratio of 1 : 3.

8. Non-metals are neither malleable nor ductile. This is due to the presence of very weak interatomic or intermolecular attractive forces.

9. The octet rule states that atoms tend to gain, lose or share electrons so that their outermost shell holds eight electrons, similar to the noble gases.

10. Aluminium. Its relative abundance is 8.1%.

11. Oxygen. Its relative abundance is 46.6%.

12. The high density of metals is due to the presence of close-packed structure in which strong attractive forces exist between the atoms of metals.

13. Non-metals are not lustrous due to the absence of free electrons.

14. Aluminium.

15. Manganese oxide (MnO_2) and Chromium oxide (Cr_2O_3).

16. Ne, P, N, Cl, Se, H are non-metals.

As and Ge are semi-metals.

Bi and Co are metals.

17. The elements which exhibit the properties of metals as well as non-metals are known as semi-metals. For example, silicon, germanium, arsenic, antimony and tellurium are semi-metals.

18. Basic or amphoteric.

19. The elements like potassium, calcium, iron and aluminium are called metals because they exhibit physical and chemical properties similar to those of metals. For example, they are electropositive, form basic or amphoteric oxides, are good conductors of heat and electricity, etc.

20. Ductility

21. Malleability

22. Good conductors of heat and high melting point.

23. A metal atom behaves as if it is an assembly of positive ions called kernels [M^+] immersed in a sea of mobile electrons. There is a complete freedom of movement of valence electrons from one metal atom to the other and the valence electrons are not localised. The delocalised electrons no longer belong to one metal atom in particular but rather to the metallic crystal as a whole. Thus, each electron belongs to a number of positive ions and each positive ion belongs to a number of electrons. When an electric field is applied, the electrons move from one end to another, which causes conduction of electricity.

24. Potassium and lithium. Malleability is the property by which metals can be beaten into thin sheets without breaking.

25. Sodium

26. Sodium and potassium.

27. **d.** Arsenic

28. A protective layer of oxide is formed on the surface of the metal (aluminium) which protects it from further oxidation.

29. i. Galvanisation

ii. Alloying with Cr and Ni

30. Zinc oxide shows both acidic as well as basic behaviour. It reacts with both acid and base to form salt and water.

31. Sodium.

32. **a.** $\underset{\text{Cinnabar}}{2HgS(s)} + \underset{\text{Oxygen}}{3O_2(g)} \xrightarrow[\text{(roasting)}]{\text{heat}} \underset{\substack{\text{Mercury(II)}\\\text{oxide}}}{2HgO(s)} + \underset{\substack{\text{Sulphur}\\\text{dioxide}}}{2SO_2(g)}$

b. $\underset{\text{Calcium}}{Ca(s)} + \underset{\substack{\text{Cold}\\\text{water}}}{2H_2O(l)} \longrightarrow \underset{\substack{\text{Calcium}\\\text{hydroxide}}}{Ca(OH)_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$

33. When a strip of copper is kept immersed in a solution of silver nitrate, copper displaces silver from silver nitrate solution and forms copper(II) nitrate. The displaced silver is deposited on the copper strip. The colour of the solution also changes to pale blue due to the formation of copper nitrate.

$$Cu + 2AgNO_3 \longrightarrow Cu(NO_3)_2 + 2Ag$$

34. Metals are electropositive in nature because for metals it is easier to lose electrons to achieve an octet.

35. A thermite mixture consists of aluminium powder and a metal oxide in the ratio 1 : 3.

36. Sodium reacts with water to form sodium hydroxide.

$$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$$

37. $Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$

Calcium — Cold water — Calcium hydroxide — Hydrogen

38. $2Na + 2HCl \longrightarrow 2NaCl + H_2$

39. Zinc being more reactive than copper will displace copper from its salt solution and form zinc sulphate.

$$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$$

The colour of the solution will change from blue to pale blue.

40. $ZnCO_3(s) \xrightarrow{\text{Heat}} ZnO(s) + CO_2(g)$

Calamine — Zinc oxide

41. Potassium (K).

42. Sodium.

43. Mercury (Hg).

44. **a.** $Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$

b. No reaction

c. No reaction

45. Zn can displace copper from $CuSO_4$ while Ag cannot displace copper from its solution.

46. Silver and gold.

47. Copper and aluminium.

48. A homogeneous mixture of a metal with other metals or that of a metal and a non-metal is called alloy.

49. Acidic or neutral oxides.

50. Due to their highest melting and boiling points and stability towards oxidation, alloys are preferentially used in electrical heating devices instead of pure metals.

51. The high melting and boiling points are due to the presence of close-packed structures and strong attractive forces (called cohesive force) between the metal atoms.

52. Metals behave as good reducing agents because they are electropositive and have a tendency to lose electrons. Hence, when they lose electrons, they reduce the other reactant in the process.

53. When aluminium is used as a reducing agent, the process is called aluminothermic reaction or Goldschmidt-thermite process.

54. Advantages of carbon reduction process:

i. The cost of the process is low since the raw material, coke is cheap.

ii. This is a continuous process and extracted metal is tapped through the tap hole from time to time.

55. The reaction of iron(III) oxide with aluminium is known as thermite reaction. This reaction is highly exothermic and is used to join railway tracks and cracked machine parts.

$$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3 + Heat$$

56. The oxide of reactive metal, Al has a greater affinity for oxygen and cannot be reduced by carbon.

57. **Corrosion:** The phenomenon of deterioration or destruction of a metal when exposed to air, water or any other substance around it in the atmosphere is called corrosion.

Galvanisation: The process of coating iron objects with a thin layer of zinc to prevent corrosion is called galvanisation.

58. Antirust solutions are alkaline solutions of sodium chromate and sodium phosphate.

59. Rust is hydrated iron(III) oxide ($Fe_2O_3 \cdot xH_2O$).

60. Stainless steel is an alloy of iron. It contains chromium and nickel in addition to iron. It does not rust and is used in cutlery, utensils, machinery and ornamental pieces.

61. Minerals are the elements or compounds, which occur naturally in the earth's crust. On the other hand, ores are the minerals which contain a very high percentage of a particular metal and the metal can be extracted profitably from it. Thus, all ores are minerals but all minerals are not ores.

62. The metals low in the activity series are very unreactive. The oxides of these metals can be reduced to metals by heating alone. For example, when cinnabar (HgS, ore of mercury) is heated in air, it is converted into mercuric oxide (HgO). Mercuric oxide is then reduced to mercury on further heating. Similarly, copper, which is found as Cu_2S in nature can be obtained from its ore by just heating in air.

63. CO

64. CO

65. Aluminium

66. $3MnO_2 + 4Al \longrightarrow 3Mn + 2Al_2O_3$

67. Sodium hydroxide on coming in contact with aluminium reacts to produce flammable and potentially explosive hydrogen gas. Hence, conc. NaOH cannot be stored in aluminium containers.

68. Composition of cryolite is Na_3AlF_6 and bauxite is $Al_2O_3 \cdot 2H_2O$.

B. Short Answer Type-I Questions

1. Non-metals have low melting and boiling points because they do not possess permanent electrical polarity and the intermolecular attractive forces are very weak. It is easy to pull the molecules apart by heating.

2. **a.** Reaction of zinc with dilute nitric acid:

$$4Zn + 10HNO_3 \longrightarrow 4Zn(NO_3)_2 + 5H_2O + N_2O$$

$$5Zn + 12HNO_3 \longrightarrow 5Zn(NO_3)_2 + 6H_2O + N_2$$

b. Reaction of zinc with chlorine:

$$Zn + Cl_2 \longrightarrow ZnCl_2$$

3. Amphoteric nature of aluminium oxide can be determined by its reaction with an acid and a base. It will react with both to form a salt and water.

Basic character of aluminium oxide:

$$\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Hydrochloric acid}}{6HCl\ (dil.)} \longrightarrow \underset{\text{Aluminium chloride}}{2AlCl_3} + 3H_2O$$

Acidic character of aluminium oxide:

$$\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{Sodium aluminate}}{2NaAlO_2} + H_2O$$

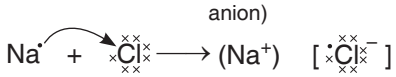
4. Na, K and Ca form hydrides by combination with hydrogen gas because they are highly electropositive metals.

5. Aluminium, although highly electropositive, does not react with water under ordinary conditions because it is protected by a thin oxide film that rapidly forms even at room temperature on nascent aluminium surfaces exposed to oxygen. This layer prevents the metal from further corrosion.

6.

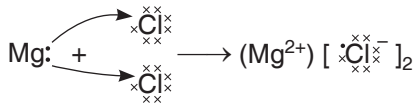
$$\underset{2,8,1}{Na} \longrightarrow \underset{\substack{2,8\\ \text{(Sodium cation)}}}{Na^+} + e^-$$

$$\underset{2,8,7}{Cl} + e^- \longrightarrow \underset{\substack{2,8,8\\ \text{(Chloride anion)}}}{Cl^-}$$



$$\underset{2,8,2}{Mg} \longrightarrow \underset{\substack{2,8\\ \text{(Magnesium cation)}}}{Mg^{2+}} + 2e^-$$

$$\underset{2,8,7}{Cl} + e^- \longrightarrow \underset{\substack{2,8,8\\ \text{(Chloride anion)}}}{Cl^-}$$



7. $Mg + 2HCl \longrightarrow MgCl_2 + H_2$

$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

$Fe + 2HCl \longrightarrow FeCl_2 + H_2$

8. Ore = Mineral + Gangue

The process of removal of unwanted materials from an ore is called concentration, dressing or benefaction of ore. Gravity separation method and froth floatation process are used for concentration of ores.

9. The oxides of metals which occur near the bottom of the activity series can be reduced to free metals by the action of heat alone. This is called self-reduction. Metals such as copper and mercury are extracted using this method.

10. Calamine. By calcination process.

C. Short Answer Type-II Questions

1. **Stainless steel**

Composition : Iron, nickel and chromium

Properties : Strong, hard, resistant to corrosion (rust proof), acid proof.

Uses : It is used for making cutlery, utensils, ornamental pieces, surgical instruments, etc.

Duralumin

Composition : Aluminium, copper, magnesium, manganese

Properties : Strong, light, resistant to corrosion, ductile, easily castable.

Uses : It is used in pressure cooker, fluorescent tube caps, aircraft, automobile and ship parts.

2. Metals appear dull on exposure to air. This happens due to the formation of a thin layer of oxide, sulphide or carbonate on metal surface. When the dull surface is rubbed with a sandpaper, the shining metallic lustre reappears.

3. In the activity series of metals, the most reactive metal occurs at the top and the least reactive

metal occurs at the bottom. Hence, the reactivity of metals decreases on moving from top to bottom in the activity series. A metal is more reactive than all other metals which are placed below it and less reactive than all the metals which are placed above it in the activity series.

4. Although hydrogen is not a metal, it is included in the activity series of metals because similar to metals, hydrogen loses electron to form the positive ion H^+.

5. **a.** The metal oxides which react with both acids and bases to form salts and water, are called amphoteric oxides. For example, aluminium oxide reacts with both an acid and a base to form salt and water.

$Al_2O_3 + 6HCl(dil.) \longrightarrow 2AlCl_3 + 3H_2O$

$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

b. X is a metal.

6. **a.** Pb **b.** Mg **c.** Ag

7. **a.** Silver metal does not react with dilute HCl because silver lies below hydrogen in the reactivity series.

b. When lead is treated with hydrochloric acid, bubbles of hydrogen gas are evolved.

$Pb + 2HCl \longrightarrow PbCl_2 + H_2$

c. The reaction of sodium metal is found to be highly explosive because sodium is highly reactive thus resulting in an exothermic reaction which leads to an increase in temperature.

d. The temperature of the reaction mixture rises when aluminium is added because it is an exothermic reaction.

8. According to the question, R is more reactive than P and Q, and P is less reactive than Q. So the following displacement reactions will take place.

i. R + Salt of Q $\longrightarrow$ Salt of R + Q

R + Salt of P $\longrightarrow$ Salt of R + P

ii. Q + Salt of R $\longrightarrow$ No reaction

Q + Salt of P $\longrightarrow$ Salt of Q + P

iii. P + Salt of R $\longrightarrow$ No reaction

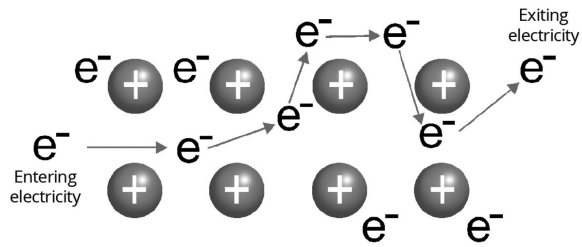
P + Salt of Q $\longrightarrow$ No reaction

The order of reactivity for P, Q and R is P < Q < R.

9. Metals have a large number of mobile electrons on their surface. These electrons absorb all the colours of white light which falls on them and go to higher energy state. They almost instantaneously come back to lower energy state and emit all the absorbed radiations. Thus, the light reflected from the surface of a metal is white and as a result metals appear lustrous.

10. When a metal is heated, the heat energy is transferred to the electrons present in the metal atoms and the electrons acquire a large amount of kinetic energy. As the electrons acquire a large amount of kinetic energy, the energetic electrons move through the metal, their energy is transferred to other electrons and other metal atoms situated at a distance away from the part being heated. Thus, heat gets conducted from one part of the metal to the other parts of the metal.

11. The free mobile electrons account for the high electrical conductivity of metals.



Conduction of electricity through a metal

12.

Ionic Compounds	Covalent Compounds
Crystalline solids (made of ions)	Gases, liquids, or solids (made of molecules)
High melting and boiling points.	Low melting and boiling points.
Conduct electricity in molten and aqueous phase.	Poor conductors of electricity in all phases.
Soluble in water but insoluble in non-polar solvents.	Soluble in non-polar solvents but insoluble in water.

13. **a.** Ionic compounds have high melting and boiling points because the ions are held together by strong electrostatic forces of attraction and a large amount of energy is required to break the strong interionic electrostatic forces of attraction.

b. Highly reactive metals cannot be obtained from their oxides by heating them with carbon because they have more affinity for oxygen than carbon.

c. When copper vessels are left exposed to air in rainy season, they get a green coating due to the formation of basic copper(II) carbonate [$CuCO_3 \cdot Cu(OH)_2$].

14. a. Sodium chloride does not conduct electricity in solid state whereas it does conduct electricity in molten state as well as in aqueous solution because in solid state movement of ions is not possible due to rigid structure and movement of ions causes electricity. In molten and aqueous state, ions are free to move, so they conduct electricity.

b. Reactivity of aluminium decreases if it is dipped in nitric acid, because nitric acid is a strong oxidising agent. As a result, when aluminium is dipped in nitric acid, a layer of aluminium oxide is formed which prevents further reaction of aluminium.

c. Metals like calcium and magnesium are never found in their free state in nature because they are highly reactive metals and form compounds with almost all elements.

15. Copper cannot displace zinc from its solution because zinc is more reactive than copper.

16. Malleability is the property by which metals can be beaten into thin sheets without breaking and ductility is the property by which metals can be drawn into thin wires. Calcium does not occur free in nature because it is a highly reactive metal and forms compounds with almost all elements.

17. Since the oxide turns red litmus blue it must be a base. Basic oxides are formed when metals get oxidised. Let us take the example of sodium.

$$4Na + O_2 \longrightarrow 2Na_2O$$

$$Na_2O + 2HCl \longrightarrow 2NaCl + H_2O$$

18. a. Non-metals

b. Metals

c. Malleability

d. Ductility

e. Alloy

19. When a substance can be beaten into thin sheets without breaking, it is said to be malleable and metals are malleable.

When a substance can be drawn into thin wires, it is said to be ductile and metals are ductile.

20. $\dot{N}a$, $\cdot\dot{\underset{\cdot\cdot}{\underset{\cdot\cdot}{Cl}}}:$

Sodium atom has only one electron in its outermost shell. So, the sodium atom donates this electron and forms the sodium ion, Na^+.

$$\underset{\text{sodium atom}}{Na} \longrightarrow \underset{\text{sodium ion}}{Na^+} + \underset{\text{electron}}{e^-}$$

Chlorine atom has 7 electrons in its outermost shell and needs one more electron to achieve the stable, 8-electron inert gas configuration. So, a chlorine atom accepts an electron and forms a negatively charged chloride ion, Cl^-.

$$\underset{\text{chlorine atom}}{Cl} + \underset{\text{electron}}{e^-} \longrightarrow \underset{\text{chloride ion}}{Cl^-}$$

When sodium reacts with chlorine, it transfers its outermost electron to the chlorine atom to form sodium ion (Na^+). By gaining one electron, the chlorine atom forms a chloride ion (Cl^-).

$$\underset{(2,8,1)}{\dot{N}a} + \underset{(2,8,7)}{\dot{\underset{\cdot\cdot}{\underset{\cdot\cdot}{Cl}}}:} \longrightarrow (Na^+) \quad [:\dot{\underset{\cdot\cdot}{\underset{\cdot\cdot}{Cl}}}:^-]$$

Sodium and chloride ions are held together by the electrostatic force of attraction to form sodium chloride or NaCl. Such a compound is said to be an ionic compound. Ionic compounds are held together by strong electrostatic forces of attraction, due to the opposing charges of the ions involved. A large amount of energy is required to break these strong forces of attraction and this gives rise to high melting and boiling points of ionic compounds.

21. a. Metals conduct electricity because they possess free electrons.

b. Reaction of metals with dilute nitric acid generally does not evolve hydrogen gas because HNO_3 is a strong oxidising agent. It oxidises the H_2 produced to water and itself gets reduced to any of the nitrogen oxides (N_2O, NO, NO_2).

22. The smell of rotten egg is given by sulphide ores because sulphur has the characteristic smell of rotten egg.

The sulphide ores are concentrated by froth floatation method. A sulphide ore is converted into metal in the following two steps:

a. $\text{Sulphide ore}(s) + O_2(g) \xrightarrow[\text{heat}]{\text{roasting}} \text{Metal oxide}(s) + SO_2(g)$

b. $\text{Metal oxide}(s) + \text{Carbon}(s) \xrightarrow[\text{heat}]{\text{reduction}} \text{Metal}(l) + CO(g)$

23. a. Hydrogen gas.

b. Electrolysis.

c. If a matchstick is brought near the mouth of the tube containing hydrogen gas, it will burn with a pop sound.

24. This process is used for the concentration of sulphide ores. This method is based on the principle that the ore particles are preferentially wetted by oil while the gangue particles are wetted by water. The powdered ore is mixed

with water and a small quantity of pine oil in a tall tank. The mixture is agitated by blowing compressed air through it when froth is formed. The froth carries with it the ore particles. The froth floats on the surface of water and is skimmed off. The gangue particles settle at the bottom of the tank. The froth is allowed to collapse and dried for recovery of ore particles.

25. **a.** $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

b. $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$

c. Reaction for electrolytic refining:

At cathode: $Cu^{2+} + 2e^- \longrightarrow Cu(s)$

At anode: $Cu(s) \longrightarrow Cu^{2+} + 2e^-$

26. The process by which the lighter gangue particles are removed from the heavier ore particles by washing with water is called lavigation or hydraulic washing. The process is based on the specific gravities of the ore and gangue particles. The powdered ore is washed with upward stream of running water, while the lighter gangue particles are washed away and the heavier ore particles are left behind.

27. Mercury occurs in nature as the sulphide ore, cinnabar (HgS). When concentrated cinnabar is roasted in the presence of excess of air, mercury(II) sulphide is converted into mercury(II) oxide which is thermally unstable and decomposes to form mercury.

$$\underset{\text{Cinnabar}}{2HgS(s)} + \underset{\text{Oxygen}}{3O_2(g)} \xrightarrow[\text{roasting}]{\text{heat}} \underset{\text{Mercury(II) oxide}}{2HgO(s)} + \underset{\text{sulphur dioxide}}{2SO_2(g)}$$

$$\underset{\text{Mercury(II) oxide}}{2HgO(s)} \xrightarrow[\text{reduction}]{\text{heat}} \underset{\text{Mercury}}{2Hg(l)} + \underset{\text{Oxygen}}{O_2(g)}$$

The equation for the overall reaction occurring during roasting of cinnabar is obtained by adding the above two equations.

$$\underset{\text{Cinnabar}}{HgS(s)} + \underset{\text{Oxygen}}{O_2(g)} \xrightarrow{\text{Heat}} \underset{\text{Mercury}}{Hg(l)} + \underset{\text{Sulphur dioxide}}{SO_2(g)}$$

28. Magnetic separation method is employed when either the ore or the impurities are magnetic in nature. The powdered ore is dropped on a conveyer belt which moves over two rollers, one of them being magnetic. When the ore particles pass over the magnetic roller, the magnetic particles of the ore are attracted by the magnetic field. The ore and gangue particles are separated in two different heaps – the magnetic particles fall nearer to the magnetic roller and the non-magnetic gangue falls farther off.

29. Metal X is aluminium and Y is Al_2O_3.

Reaction of aluminium oxide with HCl:

$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$

Reaction of aluminium oxide with NaOH:

$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

30. Coke reduces the oxides of moderately reactive metals which occur at the middle of the activity series, such as zinc, iron, tin, lead and copper, to the corresponding metals.

31. **Calcination:** The carbonate ores are subjected to calcination. Calcination is the process in which the concentrated ore is heated strongly below its melting point in the absence or limited supply of air. Calcination is used for carbonate, hydroxide [e.g. $Al(OH)_3$] or hydrated oxide (e.g. $Al_2O_3 \cdot 2H_2O$) ores.

$$\underset{\text{Limestone}}{CaCO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Calcium oxide}}{CaO(s)} + CO_2(g)$$

$$\underset{\text{Calamine}}{ZnCO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Zinc oxide}}{ZnO(s)} + CO_2(g)$$

Roasting: The sulphide ores are subjected to roasting. Roasting is the process in which the concentrated ore is heated strongly below its melting point in the presence of excess of air. Roasting is used for sulphide ores such as ZnS, HgS, etc.

$$2ZnS(s) + 3O_2(g) \xrightarrow{\text{Heat}} 2ZnO(s) + 2SO_2(g)$$

32. Metals high up in the reactivity series are extracted by electrolytic reduction while those in the middle are extracted first by converting into oxide and then reducing by carbon.

Similar process cannot be applied as metals at the top are more reactive towards oxygen than metals in the middle and metals in the middle are present in sulphide and carbonate ores.

The process used for the extraction of highly reactive metals is electrolytic reduction. The process used for the extraction of moderately reactive metals is calcination or roasting followed by reduction.

33. Froth floatation process.

The various stages involved in extraction of a metal from sulphide ore are given below:

Concentration: Concentration is done by froth-floatation. The finely powdered ore is mixed with water and pine oil in large tank. The ore particles are wetted by the oil, whereas the gangue particles are wetted by water. Air is blown through the mixture. As a result, froth

containing ore particles is formed which floats on the top of the water and can be skimmed off easily. It is dried for the recovery of ore particles.

Roasting: The concentrated ore is roasted. Roasting is done in reverberatory furnace. (taking copper as an example)

$$2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$$

Cu_2S and FeS are partially oxidised.

$$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$$

$$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$$

Reduction: It takes place in Bassemer converter. It has a basic lining inside. The little FeS present is completely oxidised to FeO and then changed into slag with reaction of silica. Cuprous sulphide reacts with Cu_2O to form blister copper.

$$Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$$

Refining of copper: The impure copper metal is purified by the process of electrolytic refining to get pure copper metal. The impure metal is made the anode and a strip of pure copper is made the cathode. These are immersed in a copper sulphate solution with a little sulphuric acid added to it. On passing electric current, the anode begins to dissolve pure copper and gets deposited on the cathode. The impurities either dissolve in the solution or get deposited below the anode as anode mud.

34. Carbonate ore.

Calcination: Carbonate ore is heated in limited supply of air and an oxide is obtained. For example,

$$ZnCO_3(s) \xrightarrow{\text{Heat}} ZnO(s) + CO_2(g)$$

Reduction with carbon: Oxide ore is then heated with carbon.

$$ZnO(s) + C(s) \longrightarrow Zn(s) + CO(g)$$

35. The reduction of a metal oxide using aluminium as the reducing agent is known as Goldschmidt–thermite process. In this process, the thermite mixture (a mixture of aluminium powder and a metal oxide in the ratio 1 : 3) is taken in a crucible. An ignition mixture (BaO_2 + Mg powder) is kept over the thermite mixture. A ribbon of Mg is inserted in the ignition mixture and the ribbon of Mg is ignited. The ignition mixture burns with the liberation of large amount of heat. At this high temperature, the aluminium powder reduces the metal oxide to metal.

36. The reaction of aluminium with iron(III) oxide is a highly exothermic reaction. The amount of heat evolved is so large that iron is produced in molten state. This is why the reaction is used for welding of cracked railway tracks because the heat produced can cause joining of cracked railway tracks.

37. The process of obtaining a metal by the electrolysis of molten salt is called electrometallurgy. Sodium is obtained by this method.

D. Long Answer Type Questions

1. Refer Table 3.8 from page 132 of the textbook.

2. a. The arrangement of metals in a vertical column in the order of decreasing reactivity is called reactivity series or activity series. A metal placed above hydrogen in the activity series will displace hydrogen from water or acids. A metal placed at the top of the activity series would displace metal below it. Thus, a more reactive metal displaces a less reactive metal from its salt solution.

b. i. For obtaining metals that are in the middle of the reactivity series, oxides of such metals can be reduced with coke (carbon) which acts as a reducing agent. For example, $2Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2$

ii. For obtaining metals that are high in the reactivity series, their oxides are reduced to metals by the process of electrolysis. For example, electrolysis of sodium chloride.

At cathode:

$2Na^+ + 2e^- \longrightarrow 2Na$

At anode:

$2Cl^- \longrightarrow Cl_2 + 2e^-$

3. a. Metals are good conductors of electricity because they possess free electrons. Non-metals are poor conductors of electricity due to the lack of free electrons.

b. Metals have a tendency to lose electrons. They lose electrons to form cations. These electrons are gained by the hydrogen ions of the acid, which form hydrogen atoms, and then these atoms combine with each other to form molecules. However, non-metals have a tendency to gain electrons. Hence, they cannot donate their electrons to hydrogen ions. This is why metals can liberate hydrogen from acids whereas non-metals cannot.

c. Iron is more reactive than copper. So, when an iron knife is dipped in copper sulphate solution, it will displace copper and form ferrous sulphate, which is green in colour.

d. Sodium is an extremely reactive metal. It reacts so vigorously with oxygen that it may catch fire if kept in the open. Hence, to protect it and to prevent accidental fires, it is kept immersed in kerosene.

e. Sodium and aluminium are very reactive metals. They have more affinity for oxygen than carbon. Hence, these metals cannot be obtained by reduction of their oxides with carbon.

4. Semi-metals are the elements which exhibit some properties of both metals and non-metals. There are seven semi-metals in the periodic table. These are B, Si, Ge, As, Sb, Po and Te.

5. a. Refer Activity 5 from page 117 of the textbook.

b. Refer Answer 27 from page 33 in Short Answer Type-II Questions.

6. a. Aluminium oxide is an amphoteric oxide because it reacts with acids as well as bases.

b. This is because iron is more reactive than copper. Iron will displace copper from copper sulphate solution and iron sulphate is formed. As there is no more copper sulphate in the solution, blue colour disapperars. As iron sulphate is formed, the solution becomes pale green.

c. Nitric acid is a strong oxidising agent so, hydrogen gas formed is oxidised to water.

d. Calcium is a reactive metal. It reacts with oxygen, water and other elements and occurs in combined state.

e. Sodium and potassium are very reactive metals. They react with oxygen so vigorously that they may catch fire if kept in open. Hence, they are kept immersed under kerosene.

7. a. The carbonate ores are changed into oxides by heating strongly in limited air. This process is called calcination.

$ZnCO_3(s) \xrightarrow{\text{Heat}} ZnO(s) + CO_2(g)$

The metal oxides are then reduced to the corresponding metals by using suitable reagents such as carbon. For, example, when zinc oxide is heated with carbon, it is reduced to metallic zinc.

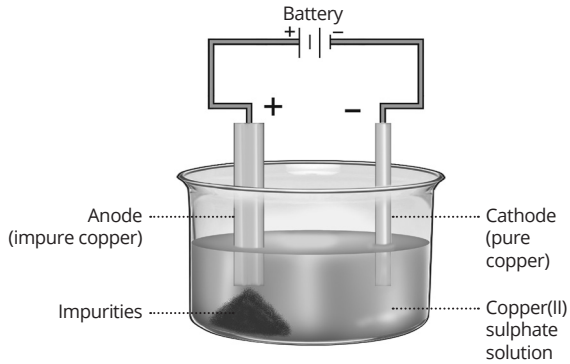
$ZnO + C \longrightarrow Zn + CO$

b. Copper is extracted from sulphide ore by the process of roasting. It is done in the presence of air.

$2Cu_2S + 3O_2 \xrightarrow{\text{Heat}} 2Cu_2O + 2SO_2$

$2Cu_2O + Cu_2S \xrightarrow{\text{Heat}} 6Cu + 2SO_2$

Electrolytic Refining of Copper



Refining of a metal by electrolysis

8. Metal X is zinc.

The sulphide ore is first heated strongly in the presence of oxygen and changed into its oxide. This process is called roasting.

$2ZnS + 3O_2 \xrightarrow{\text{Heat}} 2ZnO + 2SO_2$

Zinc oxide is then reduced to zinc metal by heating it with carbon. This process is called reduction.

$ZnO + C \xrightarrow{\text{Heat}} Zn + CO$

9. According to the reactivity series, sodium, magnesium and aluminium are more reactive than carbon. As a result, being less reactive in nature, carbon is unable to reduce oxides of Na, Mg and Al.

Metals of high reactivity such as sodium, magnesium and aluminium etc. are extracted from their ores by electrolytic reduction (electrolysis) method and they are placed above carbon in the reactivity series.

Electrolysis of molten NaCl:

At Anode: $2Cl^- \longrightarrow Cl_2(g) + 2e^-$

At Cathode: $2Na^+ + 2e^- \longrightarrow 2Na$

10. Aluminium – chemical separation and iron – magnetic separation.

11. Metal X is aluminium. The ore of aluminium is bauxite, which is concentrated by leaching. The metal is separated from its ore by electrolytic reduction, in which electrolysis of the molten oxide is carried out. This process is used for extracting aluminium because aluminium is a very reactive metal. It has more affinity for oxygen than carbon. Hence, carbon cannot be used for separating aluminium from Al_2O_3.

12. The process of removing impurities from a metal extracted from its ore is called refining of metal.

The most widely used method for refining impure metals produced by various reduction processes is electrolytic refining.

For refining copper by electrolytic refining, the impure metal is made the anode and a thin strip of pure metal (here, copper) is made the cathode. A solution of copper sulphate is used as the electrolyte. On passing current through the electrolyte, the pure metal dissolves from the anode into the electrolyte. An equivalent amount of pure metal from the electrolyte is deposited on the cathode. The soluble impurities go into the solution, whereas the insoluble impurities settle at the bottom of the anode and are known as anode mud.

At Cathode: $Cu^{2+} + 2e^- \longrightarrow Cu$

At Anode: $Cu \longrightarrow Cu^{2+} + 2e^-$

Refer figure 3.17 from page 143 of the textbook.

13. The types of reduction processes used for extraction of metals are:

i. Electrolytic reduction of fused compound (chloride or oxide of very active metal). For example, K, Na, Ca, Mg and Al.

ii. Chemical reduction of oxide by coke only. For example, Zn is obtained from ZnO by reducing it with coke.

iii. Chemical reduction of oxide by CO gas. For example, Fe is obtained from Fe_2O_3 gas by reducing it by CO gas.

iv. Self-reduction (for example, for Cu).

14. a.

Metals	Non-metals
They react with oxygen to form basic oxides.	They react with oxygen to form acidic or neutral oxides.
They react with water to produce metal hydroxide and hydrogen gas.	They do not react with water.
Metals are reducing agents.	Non-metals are oxidising agents.

b. i. In metals, electrons are free to move throughout the structure, and give rise to properties such as conductivity.

ii. $Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe + Heat$

It is a thermite reaction. This reaction is an exothermic reaction because this reaction produces a large amount of heat due to which iron metal is produced in molten form and used to join the tracks and machine parts.

15. a. i. $Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$

ii. $2HgS + 3O_2 \xrightarrow{Heat} 2HgO + 2SO_2$

iii. $3MnO_2 + 4Al \longrightarrow 2Al_2O_3 + 3Mn + Heat$

b. Alloys are the homogeneous mixture of two or more metals or one metal and a non-metal.

Properties of alloys:

1. The electrical conductivity and melting point of alloys are less than pure metals.

2. Alloys are more resistant to corrosion.

16. a. i. Native state

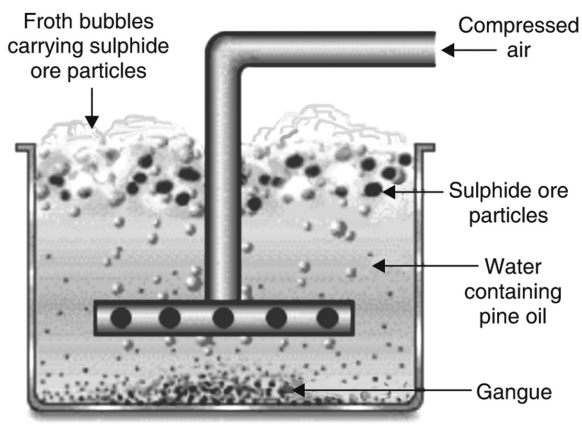
ii. Oxides, carbonates and sulphides

iii. Salts

b. i. Aluminium

ii. Iron

17. The method used to concentrate a sulphide ore is froth floatation. This method is based on the principle that ore particles are preferentially wetted by oil while the gangue particles are wetted by water. The powdered ore is mixed with water and a small quantity of pine oil in a tall tank. The mixture is agitated by blowing compressed air through it when froth is formed. The froth carries with it the ore particles. The froth floats on the surface of water and is skimmed off. The gangue particles settle at the bottom of the tank. The froth is allowed to settle and dried for recovery of ore particles.



Froth floatation process for the concentration of sulphide ores

18. The ore on reaction with dilute acid gave carbon dioxide. That means it is a carbonate ore. A carbonate is converted into metal in the following two steps:

Carbonate ore $\xrightarrow{calcination}$ metal oxide

Metal oxide + carbon $\xrightarrow{reduction,\ heat}$ metal + CO

E. Source-based / Case-based / Passage-based / Integrated Assessment Questions CBQ

1. **a.** i. **b.** iv. **c.** iii. **d.** iii. **e.** iii.

2. **a.** i. **b.** ii. **c.** iii. **d.** iii. **e.** i.

3. **a.** iii. **b.** iii. **c.** ii. **d.** iv. **e.** ii.

4. **a.** ii. **b.** iii. **c.** iii. **d.** i. **e.** iii.

F. Diagrammatic Questions

1. Refer Figure 3.5 from page 117 of the textbook.

2. Refer Figure 3.7 from page 122 of the textbook.

3. Refer Figure 3.4 from page 117 of the textbook.

4. Refer Figure 3.14 from page 139 of the textbook.

5. Refer Figure 3.17 from page 143 of the textbook.

G. Higher Order Thinking Skills (HOTS) Questions

1. Metal A is Cu and oxide B is CuO.

2. The substance A is sulphur. It is a non-metal. Its oxide will be acidic.

$$S_8 + 8O_2 \longrightarrow 8SO_2$$

a. It will have no effect on dry litmus paper.

b. it will turn moist blue litmus red.

3. Cinnabar is the ore of mercury. The steps involved in the extraction of mercury from its ore are as follows:

i. Concentration of ore: Since cinnabar is a sulphide ore, therefore, concentration of this ore is done by froth floatation method.

ii. Conversion of concentrated ore into metal oxide: This is done by roasting. When cinnabar is heated in air, it is converted into mercuric oxide.

$$2HgS + 3O_2 \xrightarrow{\text{heat}} 2HgO + 2SO_2$$

iii. Extraction of metal by the reduction of metal oxide to metal: Mercuric oxide is reduced to mercury on heating.

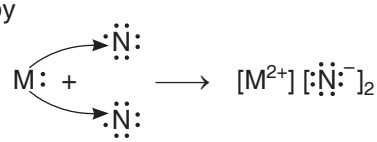
$$2HgO \xrightarrow{\text{heat}} 2Hg + O_2$$

4. The metals which lie at the top of the activity series are very reactive. They cannot be obtained from their compounds by heating with carbon. This is because these metals have more affinity towards oxygen than carbon. These metals are obtained by electrolytic reduction.

5. We are given that metal M has two electrons in its valence shell. Therefore, its electron dot structure is :M.

Similarly the electron dot structure of N is $\cdot\ddot{N}:$.

The formation of compound between M and N is given by



The bond formed between M and N will be ionic. Since MN_2 is an ionic compound, it will be soluble in water.

6. We are given that the oxide when dissolved in water turns blue litmus red. This means that the oxide is an acidic oxide. Also, acidic oxides are formed by non-metals. So, A is a non-metal.

7. Aluminium is more reactive than zinc, copper and iron. So, when aluminium is added to test tubes containing aqueous solutions of $ZnSO_4$, $CuSO_4$ and $FeSO_4$, colour change is observed due to displacement reactions. In test tube A, aluminium will displace zinc from $ZnSO_4$. The reaction that takes place is as follows:

$$2Al + 3ZnSO_4 \longrightarrow Al_2(SO_4)_3 + 3Zn$$

In test tube B, aluminium will displace copper from $CuSO_4$. The blue colour of the solution will also fade away. The reaction that takes place is as follows:

$$2Al + 3CuSO_4 \longrightarrow Al_2(SO_4)_3 + 3Cu$$

In test tube C, aluminium will displace iron from $FeSO_4$. The green colour of the solution will also fade away. The reaction that takes place is as follows:

$$2Al + 3FeSO_4 \longrightarrow Al_2(SO_4)_3 + 3Fe$$

8. The metal M is iron. It reacts with sulphur to form ferrous sulphide (N). The equation for the reaction is as follows:

$$Fe + S \longrightarrow FeS$$

The reaction of iron with steam is as follows:

$$3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$$

Hence, the compound N is FeS and compound A is Fe_3O_4.

9. **a.** Sodium chloride.

b. Sodium chloride, because it is an ionic compound whereas carbon tetrachloride is a covalent compound.

c. Sodium chloride, because it is an ionic compound and ionic compounds in molten and aqueous state conduct electricity.

d. Sodium chloride.

10. The given oxide is basic.

11. We are given that the formula of oxide is M_2O_3 and it is amphoteric. So, metal M is aluminium

and its oxide is Al_2O_3. Its amphoteric nature can be shown by the following equations:

$$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$$

$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$

12. Thermite reaction:

$$Fe_2O_3 + 2Al \longrightarrow 2Fe + Al_2O_3 + Heat$$

13. The given metal is sodium. Its chloride salt is sodium chloride, which is used as common salt. It is a very reactive metal. It reacts violently with oxygen and may catch fire if kept in the open. Hence, to protect it and to prevent accidental fires, the metal is stored under kerosene.

14. The solution is aqua regia. It is a mixture of HNO_3 and HCl in a molar ratio of 1 : 3.

15. Magnesium reacts with hot water to form magnesium hydroxide and hydrogen gas. It starts floating on the surface of water due to the bubbles of hydrogen gas sticking to its surface.

16. a. The most reactive metal is magnesium.

b. The least reactive metal is silver.

c. Ag < Fe < Zn < Mg

d. The reactions involved are as follows:

Reaction of Mg with $AgNO_3$, $ZnSO_4$ and $FeSO_4$:

$$2AgNO_3 + Mg \longrightarrow Mg(NO_3)_2 + 2Ag$$

$$ZnSO_4 + Mg \longrightarrow MgSO_4 + Zn$$

$$FeSO_4 + Mg \longrightarrow MgSO_4 + Fe$$

Reaction of Zn with $AgNO_3$ and $FeSO_4$:

$$2AgNO_3 + Zn \longrightarrow Zn(NO_3)_2 + 2Ag$$

$$FeSO_4 + Zn \longrightarrow ZnSO_4 + Fe$$

Reaction of Fe with $AgNO_3$:

$$2AgNO_3 + Fe \longrightarrow Fe(NO_3)_2 + 2Ag$$

H. Value-Based Questions (Optional)

1. a. The metals which lie at the bottom of the activity series are the least reactive. The oxides of these metals can be reduced to metal by heating alone. Hence, the metals are extracted by first converting the ore into oxide and then heating the oxide.

The metals present in the middle of the activity series are first converted into oxides. These oxides are then reduced to suitable metals by using reducing agents such as carbon, carbon monoxide, etc. Besides carbon, highly reactive metals like calcium, aluminium, etc. can also be used. The metals at the top of the activity series are obtained by electrolytic reduction of their salts.

b. Refer answer **a.** given above.

c. The metals present in the middle of the activity series find maximum industrial application. This is because they are moderately active, possess high strength and are found in abundance in the earth's crust.

d. The metals present in the middle of the activity series can be protected by

i. coating with oil or grease.

ii. covering with paint, plastic, rubber or ceramic.

iii. electroplating.

iv. alloying.

e. Caring, concern for others and scientific awareness.

2. a. Pure gold is 24 carat gold. It is very soft and hence unsuitable for making jewellery. 22 carat gold is an alloy which contains 22 parts of pure gold and 2 parts of copper or silver.

b. The goldsmith's advice was valuable because pure gold is very soft and unsuitable for making jewellery. Alloying it with copper or silver makes it hard.

3. a. The full form of PVC is polyvinyl chloride.

b. PVC is an insulator.

c. We learn values like scientific awareness, concern for others from Rajat's behaviour.

4. a. Anodising is a process of coating a thick protective oxide layer on aluminium articles by electrolysis.

b. The architect's advice is useful because the aluminium oxide coating makes the metal resistant to further corrosion. Such a protective layer is not formed in case of iron, which rusts easily.

c. Calorised iron frame can be used for this purpose. It has high surface hardness and improved resistance to oxidation. The aluminium oxide layer provides increased protection in the most hostile atmospheres.

d. We learn values like honesty, caring nature from the architect's advice.

P. 163–164 TEST PAPER

1. a. Metals are lustrous which means that they have a shining surface.

b. Metals cause the reduction of the species they react with. Hence, they are reducing agents.

c. Metals are electropositive which means they have a tendency to lose electrons and form positive ions.

2. Metals have high melting points due to the presence of close-packed structures and strong attractive forces (called cohesive force) between metal atoms.

3. Metals are malleable because the bonds holding the metal atoms are not rigid and the metal atoms can easily be moved from one lattice site to another by application of force. There are strong attractive forces which hold the metal atoms of the sheet together without breaking the metallic structure.

4. Aluminium is the most abundant metal in the earth's crust.

5. a. Roasting: The process of strongly heating concentrated ore below its melting point in the presence of excess of air is called roasting.

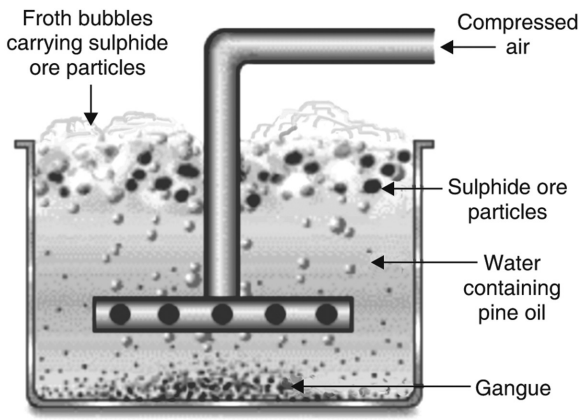
b. Calcination: The process of strongly heating an ore below its melting point in the absence or limited supply of air is called calcination.

c. Anodising: The process of coating a thick protective oxide layer on aluminium articles by electrolysis is called anodising.

6. a. Electrolytic refining refers to the process of removing impurities from metals extracted from their ores. In this method, a thick plate of impure metal is made as the anode and a thin plate of pure metal is made the cathode in an electrolytic cell. The electrolyte consists of an aqueous solution of a salt of the metal. When electric current is passed, the anode undergoes dissolution while pure metal is deposited on the cathode. The insoluble impurities deposit at the bottom of the anode as anode mud.

b. A freshly prepared mixture of concentrated HCl and concentrated HNO_3 in the ratio 3 : 1 is called aqua regia. It is used for dissolving noble metals like gold and platinum.

7. The method used to concentrate a sulphide ore is froth floatation. This method is based on the principle that ore particles are preferentially wetted by oil while the gangue particles are wetted by water. The powdered ore is mixed with water and a small quantity of pine oil in a tall tank. The mixture is agitated by blowing compressed air through it when froth is formed. The froth carries with it the ore particles. The froth floats on the surface of water and is skimmed off. The gangue particles settle at the bottom of the tank. The froth is allowed to settle and dried for recovery of ore particles.



Froth floatation process for the concentration of sulphide ores

8. Selenium and boron.

9. Sodium and potassium.

10. There will be no reaction because silver is less reactive than copper and hence cannot displace copper from its solution.

CHAPTER – 4

CARBON AND ITS COMPOUNDS

P. 188 Check Your Progress 1

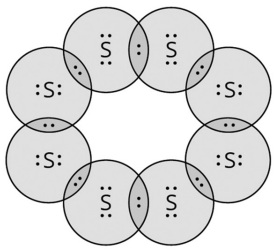
1. Methanoic acid

2. The property to form compounds with long chains, branched chains and rings of identical atoms is called catenation. Due to catenation, carbon is capable of forming a large number of compounds. Carbon exhibits the unique property to form bonds with other carbon atoms and displays catenation.

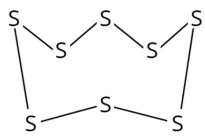
3. Hexane, C_6H_{14}

4. Propane

5.



Electron-dot structure of S_8 molecule



Crown shaped S_8 molecule

P. 193 Check Your Progress 2

1. a. $CH_3OH + [O] \xrightarrow{K_2Cr_2O_7/H_2SO_4} HCHO$

b. $C_2H_5OH + H_2SO_4(conc.) \xrightarrow[-H_2O]{170°C} CH_2 = CH_2$

c. $C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O + Heat$

d. $2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$

2. Ethanol reacts with sodium metal to form sodium ethoxide with the evolution of hydrogen.

$2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$

3. Methanol, pyridine, copper sulphate and a green or purple dye.

4. a. $C_2H_5OH \xrightarrow{5\% \text{ alkaline } KMnO_4, \text{ heat}} CH_3COOH$

Ethanol undergoes oxidation in the presence of alkaline potassium permanganate to form ethanoic acid.

b. $C_2H_5OH \xrightarrow[-H_2O]{\text{conc. } H_2SO_4, 443K} CH_2 = CH_2$

Ethanol undergoes dehydration when heated with conc. H_2SO_4 to form ethene.

Uses of ethanol:

i. It is used as a solvent for paints, varnishes, gum, resin, perfumes, oils and fats.

ii. It is used for the preservation of biological specimens.

P. 198-199 Check Your Progress 3

1. i. Reaction with alkalis: It reacts with alkalis to form salt and water.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + H_2O$$

ii. Reaction with carbonates: It reacts with metal carbonates to form salt, water and gives out carbon dioxide gas with an effervescence.

$$\underset{\text{Ethanoic acid}}{2CH_3COOH} + \underset{\text{Sodium carbonate}}{Na_2CO_3} \longrightarrow \underset{\text{Sodium ethanoate}}{2CH_3COONa} + H_2O + CO_2$$

2. Dry hydrogen chloride gas.

3. Sodium salt on heating with sodalime (NaOH + CaO) gives methane. This process is called decarboxylation.

$$\underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{Methane}}{CH_4} + \underset{\text{Sodium carbonate}}{Na_2CO_3}$$

4. When sodium hydrogencarbonate is treated with ethanoic acid, an effervescence of a gas (carbon dioxide) is formed. When this gas is passed through lime water, lime water turns milky due to the formation of white precipitate of calcium carbonate.

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2\uparrow$$

$$\underset{\text{Lime water}}{Ca(OH)_2} + CO_2 \longrightarrow \underset{\text{Calcium carbonate}}{CaCO_3\downarrow} + H_2O$$

5. a. $2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + H_2\uparrow$

b. $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

c. $CH_3COOH + C_2H_5OH \xrightarrow[\text{Heat}]{\text{Conc } H_2SO_4} CH_3COOC_2H_5 + H_2O$

6. i. Ethanoic acid is used as vinegar in food dressings and as preservative in pickles.

ii. It is used in the manufacture of rayon, celluloids, dyes and perfumes.

7. a. 5–8%

b. sodalime

c. $K_2Cr_2O_7/H_2SO_4$ or $KMnO_4/NaOH$

d. conc. H_2SO_4

8. a. T **b.** T **c.** T **d.** F

9. The carboxylic acid can be distinguished from alcohol by performing the following tests:

i. Test with $NaHCO_3$ solution in water: By adding carboxylic acid to $NaHCO_3$, carbon dioxide is liberated with brisk effervescence.

On adding a solution of $NaHCO_3$ to alcohol, no brisk effervescence occurs.

ii. **Test with blue litmus solution:** Carboxylic acid turns blue litmus red. There will be no change in colour when a blue litmus solution is added to alcohol.

P. 206 Check Your Progress 4

1. Soaps are the sodium or potassium salts of long chain fatty acids. Soap is precipitated by the addition of sodium chloride. Due to common ion effect of sodium chloride, the solubility of soap in water decreases and it floats on water. It is then skimmed off and washed with water.

2. i. Soaps are obtained from vegetable oils and animal fats while synthetic detergents are obtained from coal tar and petroleum.

ii. Soaps are biodegradable while detergents are non-biodegradable.

iii. Soaps do not form lather in hard water while synthetic detergents readily form lather in hard water.

3. Hard water contains the chlorides and sulphates of calcium and magnesium. When soap is used for washing clothes with hard water, a large amount of soap is wasted since soap reacts with calcium and magnesium ions of hard water to form insoluble precipitates called scum.

$2C_{17}H_{35}COONa + Ca^{2+} \longrightarrow (C_{17}H_{35}COO)_2Ca + 2Na^+$

The insoluble precipitates of calcium stearate and magnesium stearate stick to the clothes and thereby interfere with the cleansing ability of the additional soap. Hence, the cleansing of clothes becomes difficult.

4. **a.** sodium **b.** poorer **c.** Detergents **d.** more

5. **a.** T **b.** T **c.** T **d.** F (builder = 12%) **e.** F

6. A soap is a water-soluble compound which is made by a process called saponification. When soap is dissolved in water, alkaline NaOH or KOH is formed, making the solution alkaline. The red litmus turns blue in the soap solution, but the blue litmus stays blue in the solution.

7. Detergents are chemically sulphate or ammonium or sulphonate salts of long chain hydrocarbons.

Merits:

1. They can be used in hard water.
2. They are better than soap having stronger cleansing action.

Demerits:

1. They are non-biodegradable.
2. They are harmful to skin.

Detergents are sulphonate, sulphate or ammonium salt of long chain hydrocarbons containing 12–18 carbon atoms. These are a family of compounds that are similar to soap but do not form an insoluble precipitate with calcium and magnesium ions like soaps, making them suitable for washing, even in hard water.

P. 209 EXERCISES

A. Objective Type Questions

I. Choose the most appropriate answer.

1. a	**2.** b	**3.** b	**4.** b	**5.** c
6. c	**7.** b	**8.** a	**9.** b	**10.** c
11. b	**12.** c	**13.** a	**14.** d	**15.** a
16. d	**17.** c	**18.** b	**19.** b	**20.** a
21. c	**22.** c	**23.** d	**24.** d	**25.** d
26. c	**27.** c	**28.** d		

II. Write True or False.

1. T	**2.** T	**3.** F	**4.** T	**5.** T
6. F	**7.** F	**8.** F	**9.** T	**10.** T
11. T	**12.** T	**13.** T	**14.** T	**15.** F
16. T	**17.** F	**18.** T	**19.** T	**20.** F

III. Fill in the blanks.

1. saturated, C_nH_{2n+2}
2. catenation
3. unsaturated
4. alkenes
5. ethanoic acid
6. sodium, higher, soap
7. saponification
8. butane
9. water-soluble, water-repellent
10. triglycerides
11. methanol
12. C, H_2
13. CO_2, H_2O
14. conc. H_2SO_4
15. dehydration
16. Detergent
17. acidic

IV. Match the items in column A with the items in column B.

1. c	**2.** a	**3.** d	**4.** e	**5.** f
6. b				

V. Assertion–Reasoning Type Questions CBQ

1. a **2.** a **3.** c **4.** b **5.** b
6. d **7.** d **8.** b **9.** a **10.** c

VI. Very Short Answer Type Questions

1. Carbon does not form C^{4+} cation because a huge amount of energy is required to remove four electrons.

2. A cube can be converted into a tetrahedron by connecting the centre of the cube with four opposite corners of the cube.

3. The names and structures of first four members of alkanes are:

Name	Structure(s)
Methane	CH_4
Ethane	$CH_3—CH_3$
Propane	$CH_3CH_2CH_3$
Butane	$CH_3CH_2CH_2CH_3$

4. Octane, formula: C_8H_{18}

5. Coal is not an allotrope of carbon. It is a mixture and is composed of compounds containing C(83–93%), H(3–5%), N(0.7–2%), O(3–10%) and P(trace), along with water and non-combustible inorganic matter.

6. Graphite is converted into diamond by heating it at 1600 °C and 5000 atm pressure.

7. Fullerenes are a special class of crystalline carbon allotropes. Fullerenes are poor conductors of electricity and are readily soluble in non-polar solvents.

8. Fullerene

9. Fullerenes are used for the preparation of diamond, nanomaterials, transistors, rectifying diodes, photodiodes, photovoltaic and photorefractive devices. They are used as catalysts, superconductors, lubricants, sensors and in the refinery industry.

10. Heptane (C_7H_{16}), octane (C_8H_{18}) and nonane (C_9H_{20}).

11. The saturated hydrocarbons are relatively unreactive under ordinary conditions and are therefore called paraffins.

12. Hydrocarbons having the same molecular formula but different structural formulae are called isomers. The isomers of pentane are 2-methylbutane and 2,2-dimethylpropane.

13. **a.** Halogen **b.** Alcohol

14. Nickel

15. A reaction in which one atom in a molecule is replaced by another more reactive atom or group of atoms, without disturbing the structure of the rest of the molecule, is called substitution reaction.

16. Ethanol undergoes oxidation to form ethanal in the presence of acidified potassium dichromate or alkaline potassium permanganate.

$$C_2H_5OH \xrightarrow[K_2Cr_2O_7/H_2SO_4]{[O]} CH_3CHO$$

17. The process of preventing the use of ethanol for beverage purposes by adding poisonous materials is called denaturation.

18. By reacting with ethanol in the presence of conc. sulphuric acid.

$$CH_3COOH + C_2H_5OH \xrightarrow[Heat]{\text{conc. } H_2SO_4} CH_3COOC_2H_5$$

19. Methane

20. The alkaline hydrolysis of fats or oils to give glycerol and sodium salts of fatty acids is called saponification.

21. The solution left behind after the removal of soap contains glycerol, sodium chloride, unused sodium hydroxide and some soluble soap. This is called spent lye which is used for the recovery of a valuable by-product glycerol.

22. A cluster of about 100 soap molecules in water is known as micelle. It is spherical in shape and is formed when soap is dissolved in water. We know that a soap molecule consists of a hydrophobic tail and a hydrophilic head. In micelles, the hydrophobic tails are in the interior of the cluster and the ionic hydrophilic ends are on the surface of the cluster.

23. Synthetic detergents are cleansing agents which clean clothes without forming any insoluble scum. These are generally ammonium or sulphonate salts of long chain hydrocarbons.

24. Carbon and its compounds are used as fuels because they undergo combustion in the presence of air with the liberation of large amount of heat.

25. $C_{x-1}\ H_{y-2}$

26. Alkanes are known as paraffins. This is because alkanes are saturated hydrocarbons and are relatively unreactive under ordinary conditions.

27. A saturated hydrocarbon is one in which the carbon atoms are linked to one another by single covalent bonds.

28. **a.** gas **b.** liquid **c.** liquid **d.** liquid

29. CH_4

30. Propane (C_3H_8)

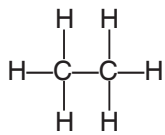
31. The reaction in which hydrogen is added to an unsaturated compound is known as hydrogenation. For example,

$$CH_2{=}CH_2 + H_2 \xrightarrow[\text{catalyst}]{\text{Ni}} CH_3{-}CH_3$$

32. Silicon carbide SiC and carbon monoxide CO.

33. The compounds of carbon in which a carbon atom is bonded to another carbon atom by a single bond are known as saturated compounds. The compounds of carbon in which a carbon atom is bonded to another carbon atom by double or triple bonds are known as unsaturated compounds.

34. The structure of ethane is written as:



Hence, there are 7 covalent bonds in a molecule of ethane.

35. Characteristics of a homologous series are as follows:

i. All the members of a homologous series are represented by the same general formula.

ii. Each successive homologue of a homologous series differs in the molecular formula by a $-CH_2-$ group.

iii. All the members of a particular homologous series have similar chemical properties.

iv. All the members of a homologous series have the same functional group.

36. The names and structural formulae of two saturated hydrocarbons are:

Name	Structural formula
Methane	CH_4
Ethane	$CH_3{-}CH_3$

37. $C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$ + Heat

38. Chlorination of methane in the presence of sunlight results in the formation of methyl chloride (CH_3Cl), dichloromethane (CH_2Cl_2), trichloromethane ($CHCl_3$) and carbon tetrachloride (CCl_4). A mixture of products is obtained because the process of chlorination does not stop at methyl chloride.

39. Ethene can be converted into ethane by carrying out the hydrogenation of ethene in the presence of nickel/palladium/platinum as catalyst.

$$H_2C{=}CH_2 + H_2 \xrightarrow{\text{Ni catalyst}} H_3C{-}CH_3$$

40. Since alcohols are neutral, they will not change the colour of *p*H paper. Hence, we can use *p*H paper, or a universal indicator to show that alcohols are neutral.

41. The uses of methanol are as follows:

i. It is used as a solvent for paints, varnishes, gum, resins, celluloids, oils and fats.

ii. It is used for denaturing ethanol, rendering it unfit for human consumption.

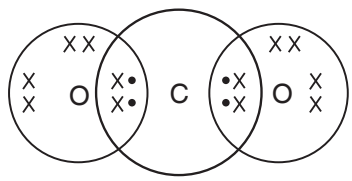
42. Sodium ethanoate can be decarboxylated by heating it with sodalime.

$$CH_3COONa \xrightarrow[\text{Heat}]{(NaOH + CaO)} CH_4 + Na_2CO_3$$

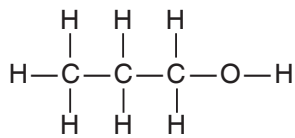
43. **i.** Ethanoic acid is used as vinegar in food dressings.

ii. It is used as a coagulating agent to obtain rubber.

44. Electron dot structure of CO_2:



45. Propanol,



46. Open chain: Butane and branched chain: isobutane.

47. Carbon forms compounds mainly by covalent bonding because it cannot complete its octet by gaining or losing four electrons.

48. Hydrocarbon A.

49. Propane and butane.

50. Alkanes are saturated hydrocarbons in which the carbon atoms are connected to one another by single bonds. Their general formula is C_nH_{2n+2}, where '*n*' is an integer.

51. The general formula for the homologous series of functional group –Cl is $C_nH_{2n+1}Cl$.

The first two members of this series are:

i. $CH_3{-}Cl$ (Chloromethane)

ii. $CH_3CH_2{-}Cl$ (Chloroethane)

52. Alcohols have a functional group –OH while alkanes do not have –OH functional group.

53. The following raw materials are needed for the manufacture of soap:

i. Vegetable oil or animal fat

ii. Sodium hydroxide solution

iii. Common salt

iv. Talc

54. An example of a cyclic unsaturated carbon compound is cyclobutene.

55. It is not possible to have an alkane with 13 hydrogen atoms. This is because the general formula of alkane is C_nH_{2n+2}. So, the number of hydrogen atoms in alkanes would always be a multiple of 2.

56. $CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl$

57. Alcohol in which small amount of methanol and other poisonous substances are added to make it unfit for drinking is called denatured alcohol.

58. C_nH_{2n+1} OH. Functional group: Hydroxyl (OH) group

59. CH_3OH and CH_3CH_2OH.

60. Drinking denatured alcohol causes blindness and cancer and in extreme cases, even death.

61. Alcohol is an intoxicant. The harmful effects of drinking alcohol are as follows:

i. Drinking alcohol slows down the metabolic processes and the reflex actions of a person and causes loss of memory and senses. It causes loss of control over the body.

ii. It causes anxiety, depression, drowsiness, insomnia, trembling hands, poor work performance and loss of self-esteem.

62. The molecular formula for first two members of the given homologous series are: CH_3Br (bromomethane) and C_2H_5Br (bromoethane).

63. A 5.8% solution of ethanoic acid in water is known as vinegar.

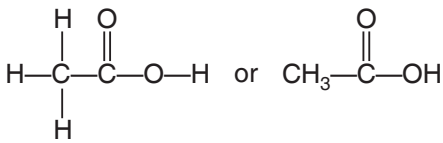
64. Structural formula: HCOOH, IUPAC name: methanoic acid.

65. $C_nH_{2n+1}COOH$

66. Methanoic acid

67. Ethanoic acid

68.



or

69. C_2H_2 and C_3H_6.

70. Acetic acid will turn blue litmus red, and it will react with base NaOH to form sodium acetate.

71. **a.** and **c.**

72. Ethanoic acid is a weak acid because it does not undergo complete dissociation in water. Hence, the number of H^+ ions furnished by acetic acid are very less.

73. Ethanoic acid

74. Oxidising agents are substances which are capable of adding oxygen atom to other substances. For example, alkaline $KMnO_4$ solution and acidified $K_2Cr_2O_7$ solution.

75. **c.** and **d.**

76. Functional groups present in alcohols and carboxylic acids are –OH and –COOH respectively.

77. Ethanoic acid, chemical formula: CH_3COOH

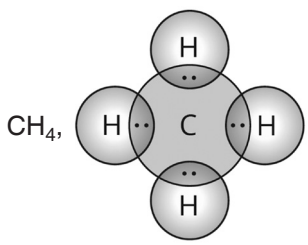
78. The general formula for the homologous series of functional group –OH is $C_nH_{2n+1}OH$. So, the molecular formulae of first two members are CH_3OH and C_2H_5OH.

79. Glycerol

80. Catenation and tetravalency

B. Short Answer Type-I Questions

1. The bond present is a covalent bond.



Electron-dot structure

2. The hydrocarbon is ethane. Its structural formula is $CH_3—CH_3$.

When ethanol reacts with sodium, sodium ethoxide and hydrogen gas are formed.

$$2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$$

3. General formula of alkanes: C_nH_{2n+2}. Methane (CH_4) and ethane (C_2H_6).

4. **a.** A decarboxylation reaction takes place, that is, carbon dioxide is removed or eliminated from CH_3COONa to give methane and sodium carbonate (Na_2CO_3). The chemical equation for this reaction is:

$$CH_3COONa + NaOH \xrightarrow{CaO} CH_4 + Na_2CO_3$$

b. Carbon dioxide and water are formed.

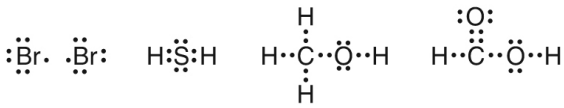
$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat} + \text{Light}$$

c. Ethene is formed.

$$C_2H_5OH \xrightarrow{\text{conc. } H_2SO_4, 170°C} CH_2{=}CH_2 + H_2O$$

d. Ethyl ethanoate is formed.

$$C_2H_5OH + CH_3COOH \xrightarrow{\text{Dry HCl gas}} CH_3COOC_2H_5 + H_2O$$

5. 

6. a. Iodopropane

b. 1,1,1-Tribromopropanone

c. 6-Bromohex-1-yne

d. 2, 3-Dibromopropanoic acid

7. Detergents are better than soaps because they have several advantages over soaps:

i. Synthetic detergents can be used even in hard water but soaps cannot be used in hard water.

ii. Synthetic detergents have a stronger cleansing action than soaps.

iii. Synthetic detergents are more soluble in water than soaps.

iii. Synthetic detergents are prepared from the hydrocarbons while soaps are prepared from animal fat or vegetable oil which leads to the latter's scarcity for human consumption.

iv. Synthetic detergents can be used even in acidic water but soaps cannot be used in acidic water.

8. Simplest carboxylic acid is methanoic acid with chemical formula HCOOH. The functional group present in acetic acid is carboxylic group, –COOH.

9. The compound is acetic acid. Its chemical formula is CH_3COOH. The functional group present in acetic acid is carboxylic group (–COOH).

10. Reactions which involve addition of two reactants to form a single product are called addition reactions. For example, addition of hydrogen gas to ethene is an addition reaction.

$$CH_2{=}CH_2 + H_2 \xrightarrow[150–250°C]{\text{Ni}} CH_3{-}CH_3$$

11. a. The reaction between an acid and an alcohol to form an ester is known as esterification. For example,

$$CH_3OH + CH_3COOH \xrightarrow[\text{warm}]{\text{conc. } H_2SO_4} CH_3COOCH_3 + H_2O$$

b. Dehydration: A reaction involving removal of water is called dehydration. For example,

$$C_2H_5OH \xrightarrow[170°C]{\text{conc. } H_2SO_4} CH_2{=}CH_2 + H_2O$$

12. a. $CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl$

b. Substitution reaction

13. i. Ethanol is used in the manufacture of alcoholic beverages.

ii. It is used as a solvent for paints, varnishes, gums, resins, perfumes and other materials.

iii. It is used for making spirit levels and thermometers.

iv. It is used as a solvent in medicines such as cough syrups, tincture of iodine and tonics.

14. To prevent the misuse of ethanol produced for industrial use, it is made unfit for drinking by adding poisonous substances. The resulting spirit is known as denatured spirit. The poisonous substances added to ethanol are methanol, pyridine, etc.

15. To precipitate the soap, sodium chloride is added during the manufacture of soaps.

16. The addition of hydrogen to an unsaturated compound is known as hydrogenation. This reaction is used in the hydrogenation of vegetable oils.

17. a. $CH_3CH_2CH_2OH \xrightarrow[\text{Heat}]{\text{alk. } KMnO_4} CH_3CH_2COOH$

It is an oxidation reaction.

b. $C_2H_4 + H_2 \xrightarrow[\text{catalyst}]{\text{Ni}} C_2H_6$

It is an addition reaction.

18. Concentrated H_2SO_4 acts as a dehydrating agent. Concentrated phosphoric acid is also a dehydrating agent.

19. a. Sodium ethoxide is formed.

$$2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$$

b. Ethanoic acid is formed.

$$C_2H_5OH \xrightarrow[K_2Cr_2O_7]{\text{acidified}} CH_3COOH$$

20. a. Ethane, common name also ethane

b. Methanol, methyl alcohol

c. Ethanol, ethyl alcohol

d. Ethanoic acid, acetic acid

C. Short Answer Type-II Questions

1. The fullerene cage formation follows three irreversible stages: nucleation of polycyclic structures by entangled carbon chains, growth by condensation of attached chains to form rings, and cage closure. The structure can be destroyed by prolonged heating.

2. a. $2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + H_2$

b. $2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$

c. $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

3. IUPAC name of ethyl alcohol is ethanol and that of acetic acid is ethanoic acid. When they react together in the presence of conc. H_2SO_4, ethyl ethanoate (ester) is formed.

$$CH_3COOH + C_2H_5OH \xrightarrow[H_2SO_4]{\text{conc.}} CH_3COOC_2H_5 + H_2O$$

4. The formula of the aldehyde is CH_3CH_2CHO. The name of this compound is propanal. The name of the given ketone is propanone. Its formula is CH_3COCH_3. The two compounds are isomers of each other.

5. Methane burns in excess of air to form carbon dioxide and water. A lot of heat is also liberated in the reaction.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat}$$

Methane reacts with chlorine to form chloromethane. However, the reaction does not stop at chloromethane as chlorine replaces the hydrogen atoms one by one. Thus, dichloromethane, trichloromethane and tetra-chloromethane are also formed.

$$CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl$$

6. a. $CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$

b. $C_2H_5OH \xrightarrow[H_2SO_4]{\text{conc.}} CH_2{=}CH_2 + H_2O$

c. $CH_3COONa + NaOH \xrightarrow{CaO,\ \text{heat}} CH_4 + Na_2CO_3$

7. A functional group is an atom or a group of atoms which determines the characteristic properties of an organic compound.

a. The functional group present in ethanol is alcohol.

b. The functional group present in ethanoic acid is carboxylic acid.

Their structures are:

CH_3CH_2OH	CH_3COOH
Ethanol	Ethanoic acid

8. C_4H_8 will show addition reaction as it is an unsaturated hydrocarbon due to the presence of double bond.

Chemical reaction for the given addition reaction:

$$C_4H_8 + H_2 \xrightarrow{Ni/Pd} C_4H_{10}$$

9. a. $CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$

b. $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

c. $C_2H_5OH + CH_3COOH \xrightarrow{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$

10. a. $2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$

b. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat}$

c. $2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$

11. C_4H_8 will show addition reaction as it is an unsaturated hydrocarbon due to the presence of double bond.

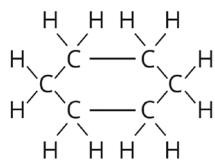
Chemical reaction for the given addition reaction:

$$C_4H_8 + H_2 \xrightarrow{Ni/Pd} C_4H_{10}$$

12. a. Carbon compounds are poor electrical conductors because they form covalent bonds, and they do not give rise to free electrons because all electrons are used to form the covalent bonds. Also, carbon compounds do not dissociate into ions, so carbon compounds are poor electrical conductors.

b. Cyclohexane

Total number of single bonds present in cyclohexane = 18



Structure of cyclohexane

13. a. 5% solution of $KMnO_4$ is prepared by dissolving 5 grams of $KMnO_4$ in 100 ml of water.

b. Alkaline potassium permanganate adds oxygen to alcohol and converts it into acid. Hence, it acts as an oxidising agent. When $KMnO_4$ is added, its purple colour disappears initially because coloured permanganate ions of potassium permanganate are consumed to oxidise ethanol.

When an excess of $KMnO_4$ is added, its colour does not change because there is no more ethanol left for the reaction.

c. The chemical equation of this reaction is given below:

$$C_2H_5OH \xrightarrow[\text{heat}]{\text{alk. } KMnO_4} CH_3COOH$$

14. A group of organic compounds having similar structure, same functional group and similar chemical properties but different physical properties, in which successive compounds differ by a $-CH_2$ group is called a homologous series. For example,

Methane: CH_4
Ethane: CH_3CH_3
Propane: $CH_3CH_2CH_3$
Butane: $CH_3CH_2CH_2CH_3$
} Alkane homologous series

General formula: C_nH_{2n+2}

Characteristics of a homologous series:

i. All the members of a homologous series have similar chemical properties.

ii. Physical properties of the series changes throughout in a regular way.

iii. All the members of a series can be prepared by almost identical methods.

15. a. Alkanes: Saturated hydrocarbons with single bond between carbon – carbon atoms (C–C).

General formula: C_nH_{2n+2}

b. Alkenes: Unsaturated hydrocarbons with double bond between carbon – carbon atoms (C=C).

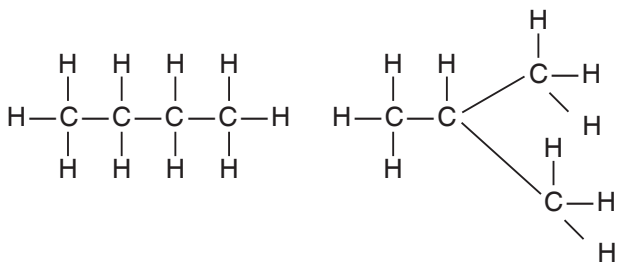
General formula: C_nH_{2n}

c. Alkynes: Unsaturated hydrocarbons with triple bond between carbon – carbon atoms (C≡C).

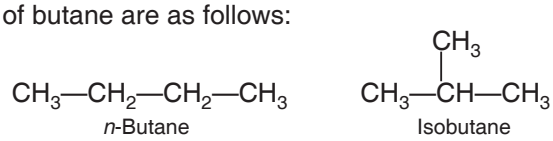
General formula: C_nH_{2n-2}

Here, C_4H_{10} is an alkane.

Structural isomer of C_4H_{10}:



16. The compounds having the same molecular formula but different structures are called isomers. The first three members of alkane series are methane, ethane and propane. These do not have sufficient number of carbon atoms to show branching. Hence, they do not show isomerism. The possible structures of isomers of butane are as follows:



17. Soap molecules are sodium or potassium salts of fatty acids. They have a polar end and a non-polar end. In a polar solvent like water, they form droplets with the non-polar tails inside, away from the solvent. A cluster formed like this is called a micelle. Such a micelle will not be formed in ethanol because the soap will get dissolved in it.

18. Detergents have replaced soaps because they have the following advantages:

i. Synthetic detergents can be used even in hard water but soaps cannot be used in hard water.

ii. Synthetic detergents have a stronger cleansing action than soaps.

iii. Synthetic detergents are more soluble in water than soaps.

iv. Synthetic detergents are prepared from the hydrocarbons while soaps are prepared from animal fat or vegetable oil which leads to the latter's scarcity for human consumption.

v. Synthetic detergents can be used even in acidic water but not the soaps.

19. A group of organic compounds having similar structure, same functional group and similar chemical properties but different physical properties, in which successive compounds differ by a $-CH_2$ group is called a homologous series. The formulae of two consecutive members of the homologous series of aldehydes are CH_3CHO (ethanal) and CH_3CH_2CHO (propanal).

a. The alkyl group of these compounds determines the physical properties.

b. The functional group of these compounds determines the chemical properties.

20. a. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat}$

b. $2CH_4 + 3O_2 \longrightarrow 2CO + 4H_2O$

c. $CH_4 + O_2 \longrightarrow C + 2H_2O$

21. A reaction in which one atom in a molecule is replaced by another more reactive atom or a group of atoms without disturbing the structure of the rest of the molecule, is called a substitution reaction.

For example, when chlorine is added to alkanes in the presence of sunlight, it replaces the hydrogen atoms one by one.

$$CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl$$

Replacement of H atom of alkane by a $-NO_2$ group.

$$CH_4 + HNO_3 \longrightarrow CH_3NO_2 + H_2O$$

22. a. *n*-butane, **b.** isopentane, **c.** cyclobutane

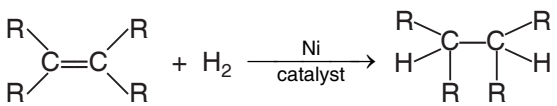
23. a. $CH_3COOC_2H_5 \xrightarrow{NaOH} CH_3COONa + C_2H_5OH$

b. $CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl$

c. $CH_3COOH + C_2H_5OH \xrightarrow[H_2SO_4]{\text{conc.}} CH_3COOC_2H_5 + H_2O$

24. Compound B with the chemical formula C_3H_6 will undergo addition reaction, as it has double bond to which the hydrogen atoms can be added.

Hydrogenation is a type of addition reaction. The hydrogenation of vegetable oils is used in the vegetable ghee industry. This reaction is represented by the following general equation of addition of hydrogen to alkenes:



25. Compound A is ethanol and compound B is ethanoic acid.

$$C_2H_5OH \xrightarrow{\text{acidified } K_2Cr_2O_7} CH_3COOH$$

26. a. The carboxylic acid is ethanoic acid (CH_3COOH).

b. The alcohol is ethanol (C_2H_5OH).

c. The compound X is ethyl acetate ($CH_3COOC_2H_5$).

27.

Soap	Synthetic detergent
Soaps are sodium or potassium salts of long-chain fatty acids containing 15–18 carbon atoms. The anionic group in soaps is —COO^-.	Detergents are sulphonate, sulphate or ammonium salts of long chain hydrocarbons containing 12–18 carbon atoms. The anionic group in synthetic detergents is —OSO_3^- or —SO_3^-.
Soaps are biodegradable.	Detergents are non-biodegradable.
Soaps cannot be used in acidic water.	Detergents can be used even in acidic water.

28. Most common soap is sodium stearate, $C_{17}H_{35}COONa$. In aqueous solution, soap ionises as follows:

$$\underset{\text{soap}}{C_{17}H_{35}COONa} \longrightarrow \underset{\text{stearate ion}}{C_{17}H_{35}COO^-} + Na^+$$

The stearate ion has two parts – the long hydrocarbon chain (R) which is hydrophobic and the negatively charged anionic part which is hydrophilic. Hence, the (R) group stays away from water and the —COO^- group dips into the water. Thus, the hydrocarbon chain of soap dissolves in oil while the ionic end of soap dissolves in water. When a large number of $RCOO^-$ groups orient themselves, an emulsion of soap in water is formed. Such a cluster of about 100 soap molecules is known as micelle.

When a cloth with oily dirt is dipped into a soap solution, the hydrocarbon chain of the stearate ion attaches itself to oils and fats and the polar end (—COO^-) is directed towards water. When shaken with water, the stearate ions form micelles containing oily dirt in the centre of the micelles. When the cloth is washed with water, the micelles containing the oily dirt are washed away and the cloth gets cleaned.

29. The reaction between a carboxylic acid and an alcohol in the presence of conc. sulphuric acid as the catalyst to form an ester is known as esterification reaction. For example, ethanoic acid on reaction with ethanol in the presence of conc. H_2SO_4 forms ethyl ethanoate.

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

Saponification reaction is the reverse of esterification. For example,

$$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$$

a. Esters are sweet-smelling substances which are used in making perfumes and as flavouring agents.

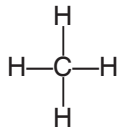
b. The process of saponification is used in the preparation of soaps.

30. The molecular formula of the acid and alcohol is C_3H_7COOH, butanoic acid and C_2H_5OH, ethanol.

31. Hard water contains chlorides and sulphates of calcium and magnesium. In hard water, the soap reacts with calcium and magnesium ions and forms insoluble precipitate called scum. The scum interferes with the cleansing ability of soap. Hence, soap does not give good lather in hard water.

D. Long Answer Type Questions

1. a. **i.**



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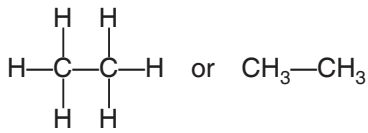

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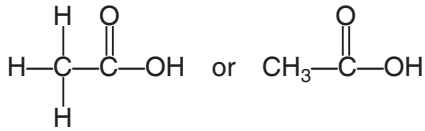
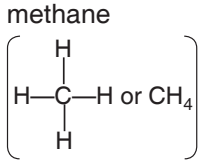


b. The given compounds are organic compounds.

c. $C_2H_5OH \xrightarrow[K_2Cr_2O_7/H_2SO_4]{[O]} CH_3CHO$

$CH_3CHO \xrightarrow[K_2Cr_2O_7/H_2SO_4]{[O]} CH_3COOH$

2. The organic compounds containing only carbon and hydrogen are known as hydrocarbons. The differences between alkanes, alkenes and alkynes are given in the following table:

Alkanes	Alkenes	Alkynes
The hydrocarbons in which carbon atoms are linked to each other by single bonds.	The hydrocarbons which contain one or more double bonds.	The hydrocarbons which contain one or more triple bonds.
These are known as saturated hydrocarbons.	These are known as unsaturated hydrocarbons.	These are known as unsaturated hydrocarbons.
Alkanes undergo substitution reactions.	Alkenes undergo addition reactions.	Alkynes undergo addition reactions.
These are represented by the general formula C_nH_{2n+2}.	These are represented by the general formula C_nH_{2n}.	These are represented by the general formula C_nH_{2n-2}.
For example, methane 	For example, ethene ($H_2C{=}CH_2$)	For example, ethyne ($HC{\equiv}CH$)

3. We are given that X is used as an antifreeze and has the formula C_2H_6O. Thus, X is ethanol. Ethanol on oxidation gives ethanoic acid. So, Y is ethanoic acid. The structural formulae are:

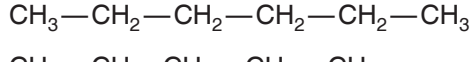
$X = CH_3CH_2OH$

$Y = CH_3COOH$

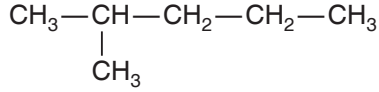
4. We are given that X is a component of wine and beer. So, X is ethanol. Its molecular formula is C_2H_5OH. Also, it is given that Y is formed by oxidation of X, and Y is a constituent of vinegar. So, Y is ethanoic acid. Its molecular formula is CH_3COOH. The equation for the conversion of X to Y is

$$C_2H_5OH \xrightarrow[\text{alkaline } KMnO_4]{\text{acidified } K_2Cr_2O_7 \text{ or}} CH_3COOH$$

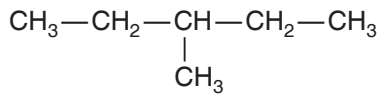
5. **i.**



ii.



iii.



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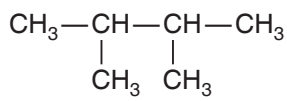
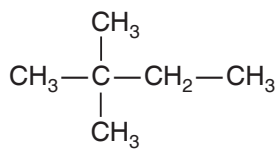
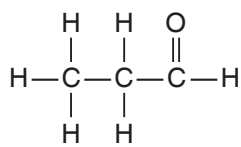


v.

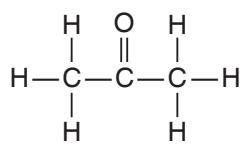


6. Isomerism is the phenomenon in which more than one compounds have the same chemical formula but different chemical structures.

The possible isomers of the compound with molecular formula C_3H_6O are:

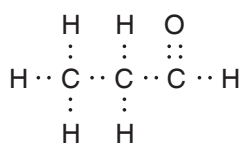


(Propanal)

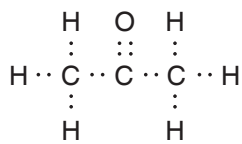


(Propanone)

Electron dot structure of propanal:



Electron dot structure of propanone:



7. i. Compound A is ethanoic acid (CH_3COOH). It reacts with sodium metal to form compound B and B is sodium ethanoate (CH_3COONa).

$$2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + H_2$$

ii. Compound D is ester or ethyl ethanoate ($CH_3COOC_2H_5$) and compound C is ethanol (C_2H_5OH).

$$CH_3COOH + C_2H_5OH \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

iii. On reaction with NaOH compound, D gives back compounds B and C.

$$CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$$

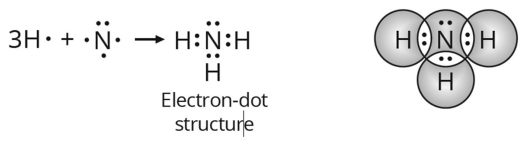
8. a. Carbon has 4 electrons in its outermost shell, and needs to gain or lose 4 electrons to attain noble gas configuration. Losing or gaining 4 electrons is not possible due to energy considerations, hence it shares electrons to form covalent bonds.

Two reasons for large number of carbon compounds are:

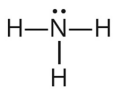
i. Catenation: The unique ability of carbon to form bonds with other atoms of carbon, giving rise to long chains of different types of compounds.

ii. Tetravalency: Carbon has a valency of 4. It is capable of bonding with four other atoms of carbon or atoms of elements like oxygen, hydrogen, nitrogen, sulphur, chlorine, etc.

b. In a molecule of ammonia, the hydrogen atom and the nitrogen atom contribute one electron each to the shared pair of electrons for the formation of each N—H bond. In the process, each hydrogen atom attains duplet of electrons and the nitrogen atom attains the octet of electrons. In NH_3 molecule, there are three N—H single covalent bonds, three bond pairs of electrons and one lone pair of electrons.



Electron-dot structure



Bond structure

9. The compound is methanol and its chemical formula is CH_3OH.

a. When ethanol is burnt in air, it forms carbon dioxide and water with the release of heat.

$$CH_3CH_2OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O + \text{Heat}$$

b. When ethanol reacts with ethanoic acid in the presence of conc. H_2SO_4, ethyl ethanoate is formed.

$$CH_3COOH + CH_3CH_2OH \xrightarrow[\text{warm}]{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

c. Ethanoic acid is formed.

$$CH_3CH_2OH \xrightarrow{\text{alkaline } KMnO_4} CH_3COOH$$

10. a.

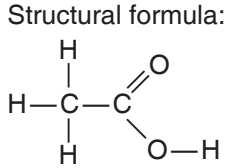
Name of the compound	Physical state	Taste	$NaHCO_3$ test	Ester test
Ethanol	Liquid	Bitter	Does not react with $NaHCO_3$	Forms ester with carboxylic acid, i.e. gives positive ester test.
Ethanoic acid	Liquid	Sour	$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$ (gives positive $NaHCO_3$ test)	Forms ester on reacting with an alcohol, i.e. gives positive ester test.

b. $$CH_3CH_2OH \xrightarrow[170°C]{\text{conc. } H_2SO_4} CH_2{=}CH_2 + H_2O$$

11. a. D is a saturated hydrocarbon.

b. B is an organic acid.

Structural formula:



c. Compound C will form ethene as the major product.

Concentrated H_2SO_4 acts as a dehydrating agent and removes a water molecule from ethanol.

$$C_2H_5OH \xrightarrow[443K]{\text{conc. } H_2SO_4} CH_2 = CH_2 + H_2O$$

d. $CH_3COOH + C_2H_5OH \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$

Major product formed is ester and it is used in making perfumes and flavouring agents.

12. The active ingredient of all alcoholic drinks is ethanol (C_2H_5OH).

Uses of ethanol:

1. It is used in medicines as solvent.

2. It is used in paints, varnishes, etc.

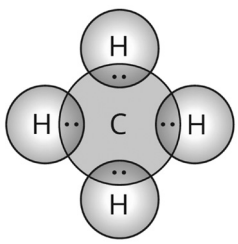
a. When ethanol reacts with sodium, the product formed is sodium ethoxide and hydrogen gas.

$2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$

b. When ethanol reacts with hot concentrated sulphuric acid, the product formed is ethene.

$C_2H_5OH \xrightarrow[170°C]{\text{conc. } H_2SO_4} CH_2{=}CH_2 + H_2O$

13. Methane is a colourless, odourless and highly flammable gas and is the main component of natural gas. The electron dot structure of methane is shown below:



Electron-dot structure

Covalent bonds are present between four hydrogen atoms and one carbon atom at the centre of the molecule.

a. Methane is a poor conductor of electricity because in methane all bonds are covalent bonds and therefore no free electrons are present in the molecule that can help in conducting electricity.

b. Covalent compounds have low intermolecular forces of attraction between the molecules and thus show low melting and boiling points. Since methane is also a covalent compound, it has very low melting and low boiling points. When methane is burnt in the presence of oxygen, it forms CO_2 and water as the products of the reaction.

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat} + \text{Light}$

14. a. When an acid ethanoic acid reacts with an alcohol in the presence of a catalyst such as concentrated sulphuric acid or dry hydrogen chloride gas to form sweet-smelling esters, the reaction is called esterification reaction. For example:

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4} \underset{\text{Ethyl ethanoate (ester)}}{CH_3COOC_2H_5} + H_2O$$

Esters undergo hydrolysis in the presence of a base (NaOH) to form alcohol and sodium salt of carboxylic acid. This reaction is called saponification reaction. Saponification is reverse of esterification.

$$\underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5} + NaOH \longrightarrow \underset{\text{Ethanol}}{C_2H_5OH} + \underset{\text{Sodium ethanoate}}{CH_3COONa}$$

b. Refer Activity 8 from page 195 of the textbook.

15. Isomers are compounds with the same molecular formula but different structural formulae.

Four characteristics of isomers are given below:

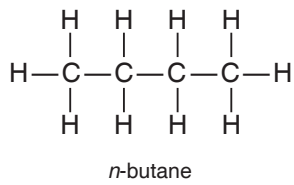
i. Isomers have different physical properties.

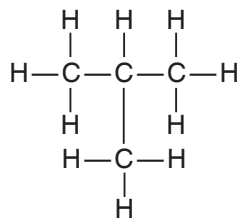
ii. Isomers may have same or different chemical properties.

iii. All isomers have the same number of atoms.

iv. Isomers have different structural arrangements.

The possible structures of butane, C_4H_{10} are given below:


n-butane


isobutane

16. Soap is prepared by the process of saponification. In this process, alkaline hydrolysis of fats or oils, which are triglycerides of long chain fatty acids, is carried out.

Most common soap is sodium stearate, $C_{17}H_{35}COONa$. In aqueous solution, soap ionises as follows:

$$\underset{\text{Soap}}{C_{17}H_{35}COONa} \longrightarrow \underset{\text{Stearate ion}}{C_{17}H_{35}COO^-} + Na^+$$

The stearate ion has two parts – the long hydrocarbon chain (R) which is hydrophobic and the negatively charged anionic part which is hydrophilic. Hence, the (R) group stays away from water and the —COO^- group dips into the water. Thus, the hydrocarbon chain of

soap dissolves in oil while the ionic end of soap dissolves in water. When a large number of $RCOO^-$ groups orient themselves, an emulsion of soap in water is formed. Such a cluster of about 100 soap molecules is known as micelle.

When a cloth with oily dirt is dipped into a soap solution, the hydrocarbon chain of the stearate ion attaches itself to oils and fats and the polar end ($—COO^-$) is directed towards water. When shaken with water, the stearate ions form micelles containing oily dirt in the centre of the micelles. When the cloth is washed with water, the micelles containing the oily dirt are washed away and the cloth gets cleaned.

17. The following raw materials are needed for the manufacture of soap:

i. Vegetable oil or animal fat

ii. Sodium hydroxide solution (20%)

iii. Common salt

iv. Talc

In laboratory, soap can be prepared by the following method:

Take 25 mL of coconut oil or cottonseed oil in a beaker. Add about 30 mL of 20% NaOH solution to it. Vigorously stir the mixture using a glass rod. The beaker will become slightly warm from the outside. Now, heat the beaker on a Bunsen burner till the mixture becomes a white paste. Remove the beaker from the flame and allow it to cool. A suspension will be formed. Add about 12–13 grams of salt to the beaker. Stir well with the help of a glass rod. Addition of salt helps in the precipitation of soap. Take a funnel and place a filter paper in it. Filter the contents of the beaker using the filter paper and funnel. The soap will be left behind on the filter paper and filtrate will pass through it. Dry this soap by transferring it on another filter paper.

18. The differences between soaps and detergents are as follows:

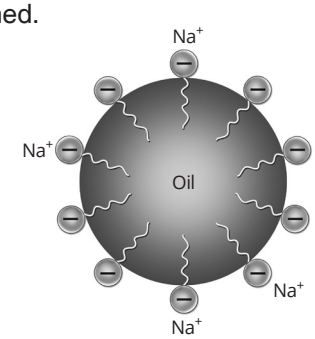
i. Soaps are sodium or potassium salts of long chain fatty acids containing 15–18 carbon atoms whereas detergents are ammonium or sulponate or sulphate salts or long chains of hydrocarbons containing 12–18 carbon atoms.

ii. Soaps can't form lather in hard water but detergents can form lather in hard water as well as soft water.

iii. Soaps are biodegradable and can be broken down into simpler substances but detergents are non-biodegradable and cannot be broken down into simpler substances.

iv. Soaps are mild cleansing agents but detergents are strong cleansing agents and are much effective in removing oil and dirt.

The cleaning action of soap in removing an oily spot from a fabric: When a dirty cloth having an oily spot is put in water containing dissolved soap, the oil is not dissolved in water. The soap molecules are salts of sodium and potassium of long-chain carboxylic acids. The acid end of soap is hydrophilic, i.e. water-loving and gets dissolved in water and the carbon chain dissolves in oil. Soap molecules form the structure of a micelle in which one end of the soap molecule is attached to the oil droplet and the other end is directed towards water. The formation of soap micelles thus removes oil particles from the surface and the surface is cleaned.



A spherical micelle formed by soap in water

Hard water contains calcium and magnesium salts. When soap is used in hard water it forms an insoluble substance called scum which remains even after washing, hence soaps are not considered suitable for washing in hard water.

Now, hard water has calcium and magnesium salts which can be removed by adding lime water. After reacting with lime water, calcium carbonate and magnesium hydroxides are precipitated and we can obtain soft water.

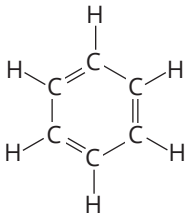
19. a. Carbon cannot form C^{4+} cation because the removal of 4 electrons requires a large amount of energy. Carbon cannot form C^{4-} anion as it would be difficult for its nucleus with 6 protons to hold on to 10 electrons.

Therefore, carbon atoms share electrons and form covalent compounds.

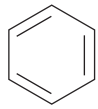
i. Covalent compounds do not dissociate into ions and hence cannot conduct electricity.

ii. Intermolecular forces of attraction between the atoms are weak in covalent compounds. Hence, they have low melting and boiling points.

b. Structural formula of benzene:



or



20. Take 25 mL of coconut oil or cottonseed oil in a beaker. Add about 30 mL of 20% NaOH solution to it. Vigorously stir the mixture using a glass rod. The beaker will become slightly warm from the outside. Now, heat the beaker on a Bunsen burner till the mixture becomes a white paste. Remove the beaker from the flame and allow it to cool. A suspension will be formed. Add about 12-13 grams of salt to the beaker. Stir well with the help of a glass rod. Addition of salt helps in the precipitation of soap. Take a funnel and place a filter paper in it. Filter the contents of the beaker using the filter paper and funnel. The soap will be left behind on the filter paper and filtrate will pass through it. Dry this soap by transferring it on another filter paper.

21. a. 3-Methylbutan-1-ol

b. 2,2-Dimethylpropan-1-ol

c. 2,2,4-Trimethylhexane

d. 1,2-Ethane diol

e. Butan-2-ol

f. 3-Methylbutan-2-one

g. 3,3-Dimethylpentane

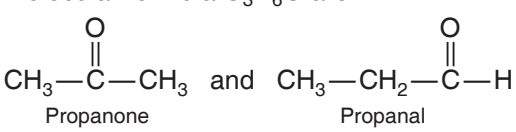
h. 3-Methylpentan-3-ol

i. 2-Chloropropan-1-ol

j. 3-Chloro-3-methylbutan-2-one

22. a. Compounds having the same molecular formula but different structural formulae are known as isomers.

b. Two possible isomers of the compound with molecular formula C_3H_6O are:



Propanone and Propanal

c. i. Ethanol can be converted into ethene by the dehydration reaction.

$$CH_3CH_2OH \xrightarrow[170°C]{\text{Conc. } H_2SO_4} H_2C = CH_2 + H_2O$$

Concentrated sulphuric acid acts as a dehydrating agent in this reaction.

ii. Propanol is converted into propanoic acid by the oxidation reaction.

$$CH_3CH_2CH_2OH \xrightarrow{\text{alkaline } KMnO_4} CH_3CH_2COOH$$

Alkaline potassium permanganate solution acts as an oxidising agent as it adds oxygen to convert propanol to propanoic acid.

23. a. Compound A is ethanoic acid.

b. $CH_3COOH + C_2H_5OH \xrightarrow{\text{conc. } H_2SO_4} \underset{\text{Compound B}}{CH_3COOC_2H_5} + H_2O$

c. By hydrolysis

d. Esterification

$$CH_3COOH + C_2H_5OH \xrightarrow[H_2SO_4]{\text{conc.}} CH_3COOC_2H_5 + H_2O$$

e. Carbon dioxide

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$$

24. a. i. Catenation: The unique ability of carbon to form bonds with other atoms of carbon, giving rise to long chains of different types of compounds.

ii. Tetravalency: Carbon has a valency of 4. It is capable of bonding with four other atoms of carbon or atoms of elements like oxygen, hydrogen, nitrogen, sulphur, chlorine, etc.

b. Those compounds which have carbon carbon single bonds only are saturated compounds whereas those compounds which have carbon carbon multiple bonds are unsaturated compounds. Unsaturated compounds are more reactive.

c. i. Bromoethane **ii.** Hexyne or Hex-1-yne

25. a. i. $CH_3COOH + C_2H_5OH \xrightarrow[H_2SO_4]{\text{conc.}} CH_3COOC_2H_5 + H_2O$

The product is ethyl ethanoate.

ii. $C_2H_5OH \xrightarrow[\text{heat (443 K)}]{\text{conc. } H_2SO_4} CH_2{=}CH_2 + H_2O$

The product is ethene.

Conc. H_2SO_4 acts as a catalyst and a dehydrating agent in the above two reactions.

b. Carbon forms large number of compounds because of tetravalency and catenation. It is a non-metal and forms covalent compounds, so it is a poor conductor of electricity. However, graphite is an exception as it is a good conductor of electricity.

26. Soaps are sodium or potassium salts of long-chain carboxylic acids, while detergents are ammonium or sulphonate salts of long chain hydrocarbons. Soaps cannot form lather in hard water, while detergents can form lather in hard water as well.

Cleansing action of soap: Soap molecules have two ends, one is hydrophilic, that is, it dissolves in water, while the other end is hydrophobic, that is, it dissolves in hydrocarbons. When soap is at the surface of water, the hydrocarbon 'tail' of soap will not be soluble in water and the soap will align along the surface of water with the ionic end in water and the hydrocarbon 'tail' protruding out of water. Inside water, these molecules have a unique orientation that keeps the hydrocarbon portion out of the water. This is achieved by forming clusters of molecules in which the hydrophobic tails are in the interior of the cluster and ionic ends are at the surface of the cluster. This formation is called a micelle. The oily dirt will be collected in the centre of the micelle. These stay in solution as a colloid. Thus, the dirt suspended in the micelles is also easily rinsed away.

Hard water contains calcium and magnesium salts. When soap is used in hard water, it forms an insoluble substance scum which remains even after washing hence soaps are not considered suitable for washing in hard water.

The following are the disadvantages of synthetic detergents:

i. Detergents (having branched hydrocarbon) are not biodegradable by microorganisms present in water bodies. Thus, they cause water pollution in lakes and rivers which become unfit for aquatic life.

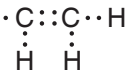
ii. Detergents are more reactive to human skin than soaps. They should not be touched with bare hands but should be handled using gloves.

E. Source-based / Case-based / Passage-based / Integrated Assessment Questions CBQ

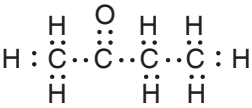
1.	**a.** i.	**b.** iii.	**c.** iv.	**d.** ii.	**e.** ii.
2.	**a.** i.	**b.** iv.	**c.** i.	**d.** iv.	**e.** i.
3.	**a.** iii.	**b.** iv.	**c.** ii.	**d.** i.	**e.** i.
4.	**a.** iv.	**b.** i.	**c.** ii.	**d.** i.	**e.** i.
5.	**a.** ii.	**b.** i.	**c.** i.	**d.** ii.	**e.** ii.

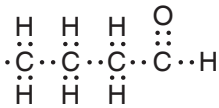
F. Diagrammatic Questions

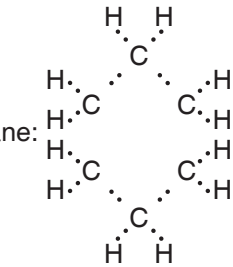
1. Refer Figure 4.2 from page 170 of the textbook.

2. Ethene: 

Ethyne: 

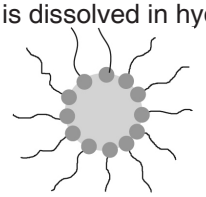
Butanone: 

Butanal: 

Cyclohexane: 

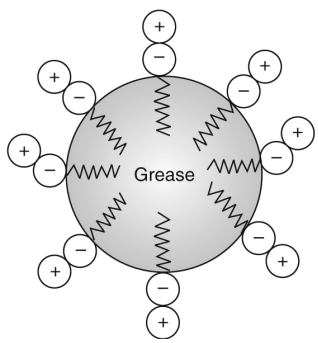
3. Refer Figure 4.7 from page 200 of the textbook.

4. When soap is dissolved in hydrocarbon.



5. Refer Figure 4.8 from page 201 of the textbook.

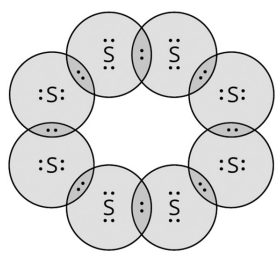
6. Cleansing action of a detergent:



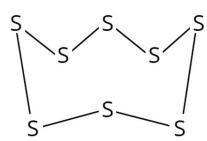
G. Higher Order Thinking Skills (HOTS) Questions

1. Carbon. Factors responsible for the stability of compounds are catenation and tetravalency.

2.



Electron-dot structure of S_8 molecule



Crown shaped S_8 molecule

3. a. HCHO and CH_3CHO

Methanal and ethanal differ by a $–CH_2$ unit and their atomic masses differ by 14 u.

b. C_2H_5CHO and C_3H_7CHO

Propanal and butanal differ by a $–CH_2$ unit and their atomic masses differ by 14 u.

In both (a) and (b), the given compounds are homologues of each other.

4. If water contains dissolved calcium carbonate, then it is hard water. Since soap forms scum with hard water but detergent works well both in hard and soft water, therefore, in this case, detergent should be used for cleaning clothes.

5. The compound P is ethanol. On reaction with conc. H_2SO_4 at 443 K, it forms ethene. Thus, compound Q is ethene. Ethene on reaction with hydrogen in the presence of nickel catalyst forms ethane. Thus, compound R is ethane.

The reactions involved are:

$$\underset{P}{CH_3CH_2OH} \xrightarrow[443\ K]{\text{conc. } H_2SO_4} \underset{Q}{CH_2{=}CH_2} + H_2O$$

$$\underset{Q}{CH_2{=}CH_2} + H_2 \xrightarrow[\text{catalyst}]{\text{Nickel}} \underset{R}{CH_3{-}CH_3}$$

$$2\underset{R}{CH_3{-}CH_3} + 7O_2 \longrightarrow 4CO_2 + 6H_2O$$

6. The compound A is ethanol. Its reaction with sodium metal results in the formation of sodium ethoxide and hydrogen gas. The equation for the reaction is as follows:

$$2CH_3CH_2OH + 2Na \longrightarrow 2CH_3CH_2ONa + H_2$$

Thus, A is ethanol, B is sodium metal and C is sodium ethoxide.

7. Compound A is ethanoic acid. Its reaction with washing soda results in the formation of carbon dioxide gas. Thus, B is carbon dioxide gas.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + CO_2 + H_2O$$

8. 10

9. Compound A is butane.

$$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$$

10. a. $CH_3COONa + NaOH \xrightarrow[\text{heat}]{CaO} \underset{A}{CH_4} + Na_2CO_3$

b. $CH_3COOH + C_2H_5OH \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4} \underset{B}{CH_3COOC_2H_5} + H_2O$

c. $CH_3COOC_2H_5 + NaOH \longrightarrow \underset{C}{CH_3COONa} + \underset{D}{C_2H_5OH}$

11. Ethanol and ethanoic acid can be differentiated on the basis of their following properties:

i. Ethanol is a liquid at room temperature with a pleasant smell. Ethanoic acid has a melting point of 17°C. Since this temperature is below the room temperature, ethanoic acid freezes during winter. It has a smell like that of vinegar.

ii. Ethanol does not react with metal carbonates while ethanoic acid reacts with metal carbonates to form salt, water and carbon dioxide. For example,

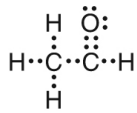
$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + CO_2 + H_2O$$

iii. Ethanol does not react with NaOH while ethanoic acid reacts with NaOH to form sodium ethanoate and water.

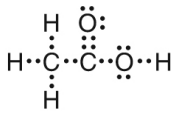
$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

iv. Ethanol oxidises to give ethanoic acid in the presence of acidified $KMnO_4$ while ethanoic acid does not react with alkaline $KMnO_4$.

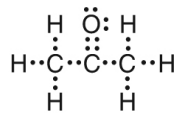
12. a.



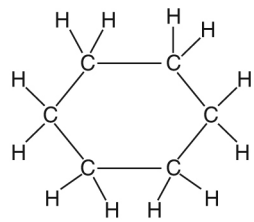
b.



c.



13. It is cyclohexane and the total number of covalent bonds present in it are 18.



14. The substance A is a soap. Soap is a salt and it partially separates into its component ions in water. The active ion of the soap molecule is $RCOO^-$. The two ends of this ion behave in different fashions. The carboxylate end ($—COO^-$) is hydrophilic (water-loving), and is said to be the "head" of the ion. The hydrocarbon portion is lipophilic (oil-loving) and is called the "tail" of the molecule. This unusual molecular structure is responsible for the unique surface and solubility characteristics of soaps and other surfactants (agents affecting the surface of a material). In a mixture of soap and water, soap molecules are uniformly dispersed. This

system is not a true solution, however, because the hydrocarbon portions of the soap's ions are attracted to each other and form spherical aggregates known as micelles. The molecule tails that are incompatible with water are in the interior of these micelles, while the hydrophilic heads remain on the outside to interact with water. When oil is added to this system, it is taken into these micelles as tiny particles. Then it can be rinsed away.

Hard water contains soluble salts of Ca and Mg. When soap is dissolved in hard water, these calcium and magnesium ions displace sodium and potassium ions from soap and thus, insoluble salts of Ca^{2+} and Mg^{2+} are formed which are called scum.

H. Value-Based Questions (Optional)

1. a. Alcohol should not be banned because:

i. It is used in the manufacture of medicines and many chemical compounds.

ii. It is commercially very useful since it is used in the manufacture of paints, varnishes, gums, resins, perfumes, etc.

iii. It is used for manufacturing of soaps, dyes and cosmetics.

Hence, alcohol is important which has many commercial uses.

b. As students, we can organise street plays to educate people about the harmful effects of consuming alcohol. We can also make posters and pamphlets on the ill-effects of alcohol so that people become more aware of it.

2. a. The process of addition of hydrogen to unsaturated compounds such as alkenes, usually in the presence of a catalyst is known as hydrogenation.

b. Saturated fats are present in animal fats. These are considered to be bad for our health since they increase the cholesterol level in our blood and cause heart problems. Vegetable oils contain unsaturated fatty acid which are healthier.

c. The student has scientific aptitude and general awareness. In addition, he also displays values such as caring nature and health consciousness.

3. a. LPG is a mixture of hydrocarbons, but mainly contains propane and butane.

b. When incomplete combustion of hydrocarbons takes place, carbon monoxide and water vapours are formed. For example, when methane is burnt in limited supply of air, it forms carbon monoxide and water vapour.

$$2CH_4 + 3O_2 \longrightarrow 2CO + 4H_2O$$

c. The student displayed qualities such as scientific awareness and concern for environment.

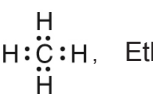
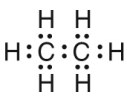
d. Incomplete combustion of fuel can be stopped by ensuring complete supply of oxygen to the fuel, and cleaning the burner so that the fuel burns properly.

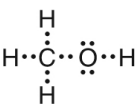
4. a. Carbon has four electrons in its valence shell. To form ionic compounds, it would either have to lose four electrons to form C^{4+} ion or gain four electrons to form C^{4-} ion. Both these processes would require a lot of energy and hence are not favoured. Thus, carbon forms covalent compounds by sharing of electrons.

b. A tetrahedron is attained from a cube. If a carbon atom is placed at the centre of the cube and hydrogen atoms are placed at alternate corners of the cube and joined to carbon atom by single bonds, a tetrahedron will be formed.

c. We can imbibe values such as sharing, being social, being helpful, etc.

P. 223 TEST PAPER

1. Methane:  Ethane: 

Methanol: 

2. The characteristics of homologous series are:

i. All the members of a homologous series are represented by the same general formula.

ii. Each successive member of a homologous series differs in the molecular formula by a —CH_2— group.

iii. The relative molecular mass of two immediate members differs by 14 u.

3. A reaction in which one atom in a molecule is replaced by another more reactive atom or group of atoms without disturbing the structure of the rest of the molecule is called substitution reaction. For example, methanol reacts with hydrogen bromide to form bromomethane.

$$CH_3OH + HBr \longrightarrow CH_3Br + H_2O$$

Methane is treated with chlorine in the presence of sunlight to form chloromethane.

$$CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl$$

4. The saturated hychocarbons react with halogens in the presence of diffused sunlight to form a number of halogenated products.

Since the halogen replaces the hydrogen atoms of a hydrocarbon one by one, the reaction is called halogenation reaction. For example, methane on halogenation forms four products such as CH_3Cl, CH_2Cl_2, $CHCl_3$ and CCl_4.

5. a. $2CH_3CH_2OH + 2Na \longrightarrow 2CH_3CH_2ONa + H_2$

b. $2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + H_2$

c. $CH_3CH_2OH \xrightarrow[\text{heat}]{\text{Cu, 300°C}} CH_3CHO$

d. $CH_3COOH + C_2H_5OH \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$

6. a. Ethanoic acid

b. Methane (CH_4) and sodium carbonate (Na_2CO_3).

7. The raw materials used for making soap are:

i. Vegetable oil

ii. Sodium hydroxide solution (20%)

iii. Common salt

iv. Talc

Soap is a salt, and it partially separates into its component ions in water. The active ion of the soap molecule is $RCOO^-$. The two ends of this ion behave in different fashions. The carboxylate end ($-COO^-$) is hydrophilic (water-loving), and is said to be the "head" of the ion. The hydrocarbon portion is lipophilic (oil-loving) and is called the "tail" of the molecule. This unusual molecular structure is responsible for the unique surface and solubility characteristics of soaps and other surfactants (agents affecting the surface of a material). In a mixture of soap and water, soap molecules are uniformly dispersed. This system is not a true solution, however, because the hydrocarbon portions of the soap's ions are attracted to each other and form spherical aggregates known as micelles. The molecule tails that are incompatible with water are in the interior of these micelles, while the hydrophilic heads remain on the outside to interact with water. When oil is added to this system, it is taken into these micelles as tiny particles. Then it can be rinsed away.

CHAPTER – 5

PERIODIC CLASSIFICATION OF ELEMENTS

P. 228 Check Your Progress 1

1. Dobereiner

2. In 1817, the German chemist John Dobereiner noticed that the elements could be arranged in the order of increasing atomic mass in the groups of three in which the atomic mass of the middle element was approximately the arithmetic mean of the atomic masses of the other two elements. The middle element had properties in between those of the other two. Such groups of elements were called Dobereiner's triads. For example, lithium, sodium and potassium have similar chemical properties and form a triad.

3. 80

4. No

5. Newlands' law of octaves states that when elements are arranged in the order of increasing atomic masses, the physical and chemical properties of every eighth element are a repetition of the first element.

Since the repetition in the properties of the first and the eighth elements is just like the repetition of the eighth note in an octave of music, Newlands' above law is called the law of octaves.

6. The first landmark attempt as a forerunner of modern periodic classification was the arrangement proposed by an English chemist, John Newlands in 1864, called the Newlands' law of octaves.

7. The law was received with ridicule specially due to the mysterious link between chemistry and music. One chemist even wondered if an equally good arrangement of elements can be obtained by alphabetising the initials of the names of the elements.

8. **i.** The law of octaves worked well only for lighter elements and could not be extended to elements of atomic masses higher than that of calcium since after Ca every eighth element did not exhibit properties similar to that of the first.

ii. Newlands assumed that only fifty-six elements existed in nature with no scope for discovery of new elements in future. Subsequently, quite a large number of new elements were discovered, the properties of which did not fit into Newlands' law of octaves.

iii. Newlands assigned one position to two elements in order to fit the elements in his periodic table. For example, only one position was assigned to Co and Ni and Ce and La.

iv. Newlands placed Co and Ni in the same column as F, Cl and Br having quite different properties in comparison to Co and Ni.

v. Newlands placed Fe far away from Co and Ni, although Fe resembles Co and Ni in properties.

Therefore, Newlands' octave was abandoned.

9. Although some marked inconsistencies existed in the classification in Newlands' time because of inaccuracies in the atomic mass data, we now find that Newlands' arrangement amounted to several horizontal series, each containing seven elements, and seven vertical groups and his arrangement has striking similarity to the Mendeleev's periodic table.

10. Chlorine, bromine and iodine are the members of the halogen group and they are called halogens since they are salt producing (Greek: *halo* = salt, *gens* = producing).

Similarities in chemical properties:

i. They are all non-metals.

ii. They all react with water to form acids (e.g., HCl, HBr, HF).

iii. They all have a valency of one (e.g., in HCl, HBr, HF).

iv. They all react with alkali metals to form neutral salts (e.g., NaCl, NaBr, NaI).

11. **a.** Dobereiner **b.** eighth, eighth **c.** eighth

12. Newlands' law of octaves states that when elements are arranged in the order of increasing atomic masses, the physical and chemical properties of every eighth element are a repetition of the first element.

Since the repetition in the properties of the first and the eighth elements is just like the repetition of the eighth note in an octave of musical scale, known as diatonic scale, in which eighth note resembles the first note.

13. **a.** False **b.** True

P. 233–234 Check Your Progress 2

1. Russian chemist Dimitri I Mendeleev (1834–1907) stated in 1869 the law of chemical periodicity: The physical and chemical properties of elements are periodic functions of their atomic masses.

2. Merits of Mendeleev's Periodic Table

i. **Systematic classification of elements:** Mendeleev's Periodic Table systematised the study of chemistry of elements and their compounds. Chemically similar elements are placed in a group and by knowing the property of one element in a group, the properties of other elements in the group can be predicted. It has reduced the study of 118 elements to that of eight groups only.

ii. **Classification on the basis of fundamental atomic property:** Mendeleev's classification of elements is based on atomic mass of elements. Atomic mass is a better fundamental property and classification based on atomic masses is a better method than classifying elements by considering atomic volume, triads, octaves, etc.

iii. **Correction of atomic masses:** Mendeleev's Periodic Table predicted errors in the atomic masses based on their positions in the Periodic Table and these were corrected. For example, atomic mass of Be was corrected from 13.9 to 9.0. The atomic masses of a few other elements such as In, au and Pt, etc. were also corrected.

iv. **Prediction of undiscovered elements:** Only 63 elements were known at the time of Mendeleev's classification of elements. He kept many vacant spaces in the Periodic Table for accommodating new elements to be discovered. he even predicted the properties of these unknown elements. Subsequently, these elements were discovered and their properties were found to be similar to those predicted by Mendeleev.

v. **Electronic configuration of elements:** Mendeleev's periodic law suggests the periodic recurrence of electronic configurations of elements and all the elements of a group have identical electronic configuration in the outermost shell.

3. Drawbacks of Mendeleev's Periodic Table

Although Mendeleev's Periodic Table has many merits, it has several defects also. These defects are listed as follows:

i. **Discrepancy in periodicity:** The arrangement of elements in the order of increasing atomic masses is not maintained in the following cases and the cause of periodicity put forward by Mendeleev is not tenable.

Pair 1		Pair 2	
Co	Ni	Te	I
58.93	58.71	127.6	126.9

In these pairs, the elements with higher atomic masses have been placed before the elements of lower atomic masses. Mendeleev's periodic law of atomic masses cannot explain these anomalies of reverse order of arrangement of elements. These anomalies occurred due to placing these elements in their correct group on the basis of their chemical properties. (Although these elements were placed in the wrong order with respect to their atomic masses, their positions are justified when their atomic numbers are taken into account, as we shall find later.)

ii. **Position of hydrogen:** Mendeleev placed hydrogen in Group I A. But hydrogen exhibits close similarities in properties with the elements of both Group I A and VII A. Hence, the position of hydrogen in the Mendeleev's Periodic Table is not correctly defined.

iii. **Position of isotopes:** Isotopes of the same element have similar chemical properties and different atomic masses and hence they should be placed in different groups according to the Mendeleev's periodic law based on atomic masses. But Mendeleev did not provide separate places to the isotopes of an element. Isotopes were discovered long after Mendeleev proposed his Periodic Table.

iv. **Position of noble gases:** Mendeleev did not provide any place for noble gases in his Periodic Table (the noble gases were not known at that time).

v. **Position of metals and non-metals:** Mendeleev's Periodic Table does not make any attempt to separate metals from non-metals.

vi. **Placement of elements with identical properties in different groups:** Elements with identical properties such as copper and mercury have been placed in Group I B and Group II B, respectively.

vii. **Placement of elements with different properties in the same group:** Elements with different properties have been placed in the same group. For example, the inactive coinage metals (Cu, Ag, Au) have been

placed with most active metals (Li, Na, K, etc.) in Group I.

viii. **Violation of one position for one element rule:** The rule of one position for one element has been violated by placing Fe, Co, Ni in Group VIII, Period 4; Ru, Rh, Pd in Group VIII, Period 5; Os, Ir, Pt in Group VIII, Period 6.

ix. **Relation between chemical properties of elements and electronic configurations of elements:** In Mendeleev's Periodic Table, there does not exist any relationship between chemical properties and electronic configurations of elements.

x. **Irregular trend in atomic masses of elements:** The atomic mass of elements does not increase in a regular manner on moving from one element to the next element. Due to this, it was not possible to predict the number of elements which could be discovered between two elements, specially in the case of heavier elements.

4. (Ar, K), (Co, Ni), (Te, I)

5. Noble gases

6. 63

7. *Eka*-boron, *Eka*-aluminium, *Eka*-silicon

8. Be, In

9. Ga

10. 6, 8

11. **a.** atomic mass **b.** periods **c.** groups **d.** 63 **e.** Nilson, Winkler **f.** chemical properties, physical properties

12. **a.** F **b.** F **c.** F **d.** F **e.** T **f.** F **g.** F

P. 239 Check Your Progress 3

1. The physical and chemical properties of elements are periodic functions of their atomic numbers.

2. Moseley

3. **Periods:** The horizontal rows of elements in the Periodic Table are called periods. There are seven periods in the Modern Periodic Table.

Groups: The vertical columns of elements in the Periodic Table are called groups. There are eighteen groups in the Modern Periodic Table.

4. 18, groups

5. The elements of groups 1, 2 and 13 to 18 are called representative elements (or main group elements). The chemical properties of the representative elements are determined by the number of valence electrons in their atoms.

6. **a.** Group 1 – alkali metals

b. Group 2 – alkaline earth metals

c. Group 16 – chalcogens

d. Group 17 – halogens

e. Group 18 – noble gases

7. **Explanation for the position of isotopes:** Since the isotopes of an element have the same number of protons, their atomic number is also the same. Hence, in spite of having different atomic masses, the isotopes of an element are assigned the same position in the Periodic Table.

8. 19

9. **a.** Group 2 Elements: Mg, Ca

b. Group 15 elements: N, P

c. Group 18 elements: He, Ne

10. Cs

11. Ne

12. **a.** Ca, Ra; Si, Ge **b.** Ca, Ge, As, Kr

13. **a.** 18, 7 **b.** atomic number **c.** halogens

14. **a.** 8 **b.** 18

15. The electrons present in the outermost shell of an atom of an element are called its valence electrons. They are so called because the electrons in the outermost shell determine the valency of an element.

P. 245–246 Check Your Progress 4

1. **a.** sodium **b.** krypton **c.** sulphur **d.** iodine

2. francium

3. fluorine

4. **a.** Cs **b.** Kr **c.** Sr **d.** K **e.** Sn

5. The atomic radii of elements increase with increase in atomic number on moving from top to bottom in a group. On moving down a group, a new shell of electrons is added in each succeeding element. Hence, the electrons in the valence shell of each succeeding element lie farther and farther away from the nucleus. Consequently, the attraction of the nucleus for the electrons decreases and as a result, the atomic radius increases with increase in atomic number. But the nuclear charge of elements also increases. This produces a contractive effect on the atomic radius. The increase in the atomic radius due to the addition of new shell is so large that it outweighs the contractive effect

of the increased nuclear charge. As a result, the atomic radius increases on moving down a group from top to bottom.

6. The atomic radii of elements decrease with increase in atomic number on moving from left to right in a period. On moving from left to right along a period, the nuclear charge increases by one unit in each succeeding contraction in atomic radius from left to right in a period. Thus, in any period, the alkali metal atom such as Li, Na, K, etc. has the largest atomic radius while the halogen atom has the smallest atomic radius. The atomic radius suddenly increases for the noble gas atom due to the interelectronic repulsion within a shell. Francium has the highest atomic radius and hydrogen has the smallest atomic radius.
7. X < Z < Y. The atomic radii of atoms decrease with increase in atomic number in a period from left to right.
8. Increases from 1 to 4 and then decreases to 0 .
9. 1 and 8
10. **a.** decrease **b.** increase **c.** block **d.** Al **e.** 2, 17
11. **a.** T **b.** T **c.** F **d.** T

P. 249 Check Your Progress 5

1. Ga
2. Ca
3. It will increase.
4. It will decrease.
5. It will increase.
6. It will decrease.
7. **a.** non-metal **b.** increases **c.** increases **d.** Li, F
8. **a.** T **b.** T **c.** F **d.** T
9. Group 14–16

P. 251–252 Check Your Progress 6

1. **a.** F **b.** Cl **c.** Ar **d.** Kr
2. Highest: Kr; Lowest: K
3. C
4. Due to higher atomic radius of Be (125 pm) than B (90 pm).
5. Cs
6. He
7. They are inversely related to each other.
8. Atomic radius and nuclear charge.
9. Due to lower nuclear charge and higher atomic radius.
10. Due to odd number of electrons in the valence shell of N.
11. Due to smaller atomic radius and higher nuclear charge.
12. **a.** increases **b.** increases **c.** decreases **d.** higher
13. **a.** T **b.** T **c.** T **d.** F

P. 254 Check Your Progress 7

1. **a.** Cl **b.** F **c.** S **d.** O **e.** Cl **f.** Al **g.** Li
2. I < Br < F < Cl
3. Cl
4. Because of low atomic radius of 75 pm.
5. Halogens have strong tendency to accept an electron and to form anions which have the stable electronic configuration of the nearest noble gas.
6. Due to completely filled valence shell.
7. The electron affinity of elements increases on moving from left to right in a period but not in graded manner. On moving in a period from left to right, the atomic radius decreases and nuclear charge increases. Both these factors increase the attraction of added electron by the nucleus. Hence, electron affinity increases in a period from left to right. The non-metals have greater electron affinity than metals. This is because the non-metals have strong tendency to accept electrons and to form anions which have the stable electronic configuration of the nearest noble gas.
8. The electron affinity of elements decreases on moving down a group. There is some exception: electron affinities of N, O and F (second period) are lower than those of P, S and Cl (third period), respectively. The elements of second period have the smallest atomic radius among the elements in their respective groups. Due to the smaller atomic radius, there occurs considerable electron–electron repulsion within the atom. As a result, the added electron is not accepted with the same ease like the other elements in the group. Thus, the electron affinity of nitrogen is lower than that of phosphorus. The electron affinity of oxygen is lower than that of sulphur.
9. **a.** decreases **b.** electron affinity **c.** lower **d.** increases
10. **a.** F **b.** F **c.** F
11. Be and Ne.

P. 255 Check Your Progress 8

1. Electronegativity of elements decreases on moving down a group. Due to the increase in size with increase in atomic number, the tendency of an atom to attract the shared pair of electrons decreases. Hence, electronegativity decreases on moving down a group. For example, in Group 1 elements, the order of decreasing electronegativity is: Li, 0.98 > Na, 0.93 > K, 0.82 = Rb, 0.82 > Cs, 0.79. In Group 17, the order of decreasing electronegativity is:

F > Cl > Br > I > At

Fluorine has the highest electronegativity (3.98) among all the elements in the Periodic Table. Francium has the lowest electronegativity (0.7) among all the elements in the Periodic Table.

2. Electronegativity increases in a period on moving from left to right. On moving from left to right in a period, the atomic radius decreases and the nuclear charge increases. Due to the combined effect of decreasing atomic radius and increasing nuclear charge, the shared pair of electrons is more strongly attracted towards the nucleus. As a result, the electronegativity increases in a period from left to right.

3. It decreases on moving down the group.

4. Oxygen

5. Rb

6. F

7. **a.** F, Li **b.** decreases **c.** increases **d.** higher

8. **a.** F **b.** F **c.** F **d.** F **e.** T

P. 265 EXERCISES

A. Objective Type Questions

I. Choose the most appropriate answer.

1. a	**2.** d	**3.** b	**4.** b	**5.** b
6. d	**7.** b	**8.** a	**9.** b	**10.** c
11. c	**12.** d	**13.** a	**14.** d	**15.** a
16. b	**17.** c	**18.** c	**19.** a	**20.** a
21. b	**22.** c	**23.** a	**24.** c	**25.** d
26. c	**27.** a	**28.** a	**29.** c	**30.** b
31. c				

II. Write True or False.

1. F	**2.** F	**3.** F	**4.** F	**5.** F
6. F	**7.** T	**8.** T	**9.** F	**10.** T
11. T	**12.** T	**13.** F	**14.** T	**15.** T
16. T	**17.** T	**18.** T	**19.** T	**20.** T

III. Fill in the blanks.

1. Mendeleev	**2.** groups, periods
3. 17	**4.** average
5. gallium	**6.** germanium
7. scandium	**8.** higher
9. alkali metals	**10.** halogens
11. lithium, flourine	**12.** alkaline earth metals
13. noble gases	**14.** 0
15. 1	**16.** group
17. protons	**18.** released
19. 18	**20.** decreases, increases
21. atomic mass	**22.** eighth

IV. Match the items in column A with the items in column B.

1. c	**2.** e	**3.** a	**4.** f	**5.** d
6. b	**7.** h	**8.** i	**9.** g	

V. Assertion–Reasoning Type Questions CBQ

1. a.	**2.** a.	**3.** c.	**4.** d.	**5.** a.
6. a.	**7.** d.	**8.** a.	**9.** a.	**10.** c.

VI. Very Short Answer Type Questions

1. Dobereiner's triads were sets of three similar elements arranged in the order of increasing atomic mass in which the atomic mass of the middle element was approximately the arithmetic mean of the atomic masses of the other two elements. The elements showed similar properties.

2. X is bromine.

3. When elements are arranged in the order of increasing atomic masses, the similarities in physical and chemical properties reappear after each interval of eight elements just like the eighth musical note resembles the first.

4. Atomic number is more important than atomic mass in predicting chemical periodicity because when elements are arranged in the order of increasing atomic number, a regular gradation in properties is observed. Elements with similar electronic configuration show similar chemical properties and are placed in the same group.

5. The horizontal rows in the periodic table are called periods and the vertical columns are called groups.

6. **a.** alkali metals, **b.** alkaline earth metals, **c.** chalcogens, **d.** halogens

7. The basis for Mendeleev's periodic law was atomic mass and similarity in chemical properties.

8. Atomic number of elements is the basis of Modern Periodic Table.

9. Hydrogen resembles alkali metals in the following aspects: The outermost electronic configuration of hydrogen and alkali metals is 1. Both hydrogen and alkali metals are electropositive and both lose one electron to form H^+ or M^+ ion. Like alkali metals, hydrogen combines with oxygen, sulphur and halogen to form compounds which have similar formulae. Both hydrogen monoxide and alkali metal oxides are highly stable.

10. Hydrogen resembles halogens in the following ways:

    Both hydrogen and halogens are non-metals and exist as diatomic molecules.

    Halogens are highly electronegative and accept one electron to form anions. In alkali metals, hydrides, hydrogen behaves as an anion like the halogen ion in metal halides.

    Hydrogen forms hydrides with carbon and halogens form halides.

    Like halogens, hydrogen combines with non-metals to form covalent compounds.

11. The valency of silicon is 4.

12. 14 elements

13. 14 elements

14. Importance of modern periodic table is as follows: The periodic table has simplified the study of diverse elements and their compounds. It has helped us to correlate the properties of elements with their atomic numbers and electronic configuration. The chemical reactivity of an element can be predicted from the position of the element in the periodic table. It has helped us to find relationships between various elements. Periodic table helps us to predict the properties of yet to be discovered elements.

15. The number of valence electrons increases as we move from left to right in a periodic table.

16. The number of valence electrons remains constant as we move down a group.

17. On moving from left to right in a period in the periodic table, the nuclear charge increases by one unit in each succeeding element, while the added electron enters the same shell. As a result, the electrons of all the shells are strongly pulled towards the nucleus. Hence, there is a steady contraction in atomic radius from left to right.

18. On moving down a group, new shells get added at each succeeding element. Hence, the electrons in the valence shell of each succeeding element lie farther and farther away from the nucleus. Consequently the attraction of the nucleus for the electrons decreases and as a result the atomic radius increases with increase in atomic number.

19. The elements belonging to the first group of the periodic table are alkali metals. They have the following properties:

    i. They are highly electropositive and readily lose an electron to form a unipositive ion.

    ii. They form ionic compounds.

20. Doberiener's triads are sets of three similar elements arranged in the order of increasing atomic mass in which the atomic mass of middle element is approximately the arithmetic mean of the atomic masses of the other two elements. X is Selenium.

21. The amount of energy required to remove the most loosely held electron from an isolated gaseous atom is called ionisation energy. Its unit is kJ/mole.

22. The ionisation energy increases on moving left to right in a period because of the combined effect of the increase in nuclear charge and decrease in the atomic radius.

23. On moving down a group the ionisation energy decreases because on moving down a group, the atomic size increases and the nuclear charge also increases. But the effect of increase in atomic size dominates and the force of attraction between the nucleus and outermost electron decreases. Thus, the removal becomes easy.

24. Metallic character is inversely related to ionisation energy. Since ionisation energy decreases on moving down a group, the metallic character increases on moving down a group. Since ionisation energy increases in a period from left to right, metallic character decreases in a period from left to right.

25. Because metals are electropositive and tend to lose electrons easily. Non-metals are electronegative and hold the electron strongly.

26. Electron affinity of an element is the energy released when an isolated gaseous atom accepts an electron to form gaseous negative ion. Its units are kJ/mole.

27. Non-metals have a greater electron affinity than metals because of their atomic structures – first, non-metals have more valence electrons than

metals do, thus it is easier for the non-metals to gain electrons to achieve a stable octet and secondly, the valence electron shell is closer to the nucleus, thus it is harder to lose an electron and it is easier to attract electrons from other elements (especially metals). Thus, non-metals have a higher electron affinity than metals, meaning they are more likely to gain electrons than atoms with a lower electron affinity.

28. Electronegativity of an element is the tendency of an atom in a molecule to attract a shared pair of electrons towards itself. It does not have a unit. It is only a number.

29. Electron affinity is the energy released when an isolated gaseous atom accepts one electron to form an isolated gaseous negative ion whereas electronegativity is the tendency of an atom in a molecule to attract a shared pair of electrons towards itself.

30. Mercury and bromine.

31. Hydrogen, helium, nitrogen, oxygen, neon, argon, fluorine, chlorine, bromine, krypton, xenon.

32. a. The elements with the most metallic character would be found in the bottom left corner of the periodic table.

b. The element with most non-metallic character would be found in the top right part of the periodic table.

33. The most electropositive metal would be caesium and most electronegative element is fluorine. So, a compound between the two, i.e. caesium fluoride or CsF would be the most ionic.

34. Group 18 of the modern periodic table, which comprises the noble gases, was missing in the Mendeleev's periodic table. This is because the noble gases were discovered very late as a result of their inert nature and extremely low concentrations in the atmosphere.

35. We are given that the element X has mass number 35 and the number of neutrons are 18. So, the number of protons would be 35 – 18 = 17. Since the number of protons is equal to the number of electrons, hence, the number of electrons in X = 17. The element is chlorine. Its electronic configuration is 2, 8, 7. It belongs to the 7th group and 3rd period of the periodic table. Its valency is 1.

36. The most metallic element is caesium. It belongs to group I of the periodic table.

37. John Newlands in 1864 arranged the then known elements in the order of increasing atomic masses and found that every eighth element had properties similar to that of the first. As it was similar to the octaves found in music, so this law is called 'Newlands' law of octaves'. Newlands was the first to formulate the concept of periodicity in the properties of the chemical elements.

38. The factors affecting ionisation energy are atomic radius and nuclear charge. The greater the atomic radius, the lesser is the ionisation energy and the greater the nuclear charge higher is the ionisation energy.

39. Factors affecting electron affinity are atomic radius, nuclear charge and electronic configuration. Electron affinity decreases with increase in atomic radius. Electron affinity increases with increase in nuclear charge. Elements having stable electronic configuration have low or zero electron affinity.

40. Chlorine

41. Francium

42. The reactivity of non-metals increases with increase in elctronegativity.

43. a. Increases as we go down a group.

b. Decreases as we move across a period.

44. a. On moving down a group, the elctropositivity increases.

b. On moving across a period, the electropositivity decreases.

45. Elements in a group have similar properties because they have the same number of electrons in the outermost shell.

46. Element with atomic number 14 is silicon and it is a semi-metal.

47. K (potassium)

48. Sodium

49. Chlorine

50. Mg < Si < P < O < F

51. Valency increases from 1 to 4 and then reduces to zero in the last elements of the period when we move from left to right across a period. Number of valence electrons increases from 1 to 8 when we move from left to right across a period.

52. a. K, **b.** Be, Ca

53. a. Carbon, **b.** Boron, **c.** Carbon

54. F < O < N < P < Si < Al

55. Flourine is in the second period of the periodic

table whereas chlorine is in the third period. The elements of second period have the smallest atomic radius among the elements in their respective group. Due to smaller atomic radius, there occurs considerable electron electron repulsion within the atom. As a result, the added electron is not accepted with the same ease like the other elements in the group. Hence, the electron affinity of chlorine is higher than that of fluorine.

56. **a.** I **b.** Cl

57. S < O < F

58. Remains constant

59. Group 17

60. **a.** The element with the atomic number 13 is aluminium (Al). It belongs to the 3rd period and 13th group of the periodic table.

b. The element is a metal. Aluminium shows many properties which are characteristic of metals, like conductivity, ductility, malleability, etc. Also, it is electropositive in nature and forms cations. Thus, it is a metal.

61. Li < Si < C < F < Ne

62. H < Cl < F

63. **a.** Elements at the bottom of a group have most metallic character.

b. Elements at the bottom of a group have largest atomic size.

64. Ne < N < C < Si < Mg < Na

65. Bi < Sb < As < P < N

66. Along a period A will be towards the right of B (since ionisation energy of A is more and ionisation energy increase across a period). In a group, A will be above B (since ionisation energy decrease down a group).

67. Mg

68. Beryllium, Be

69. The element with atomic number 12 is magnesium. It is present in 3rd period and 2nd group of the periodic table.

70. **a.** S **b.** P **c.** K **d.** Sr

71. Electron affinity of halogens is high because addition of one electron leads to filling of shell and attainment of stability.

72. Electron affinity of noble gases is zero because they have their outermost shell completely filled with electrons.

73. Mg < Na < K < Rb

74. Boron is a semi-metal while aluminium is a metal.

75. Since hydrogen resembles both alkali metals and halogens, no fixed position can be given to hydrogen in the periodic table. It has to separately placed. However, it is usually placed in the first group.

B. Short Answer Type-I Questions

1. Mendeleev left gaps in the periodic table for accommodating new elements that were not discovered at that time. He predicted the existence of certain elements that were discovered later. For example, he kept three vacant spaces below B, Al and Si in Group IV. He named them as eka-boron, eka-aluminium and eka-silicon, respectively. These elements were discovered subsequently and Mendeleev's prediction about the properties of these elements and their compounds was found to be precisely correct.

2. Elements which have a tendency to donate electrons are known as electropositive elements. Metals are electropositive elements. For example, sodium (Na), calcium (Ca). Elements which have a tendency to gain electrons are known as electronegative elements. Non-metals are electronegative elements. For example, fluorine, chlorine, etc.

3. The element with the atomic number 16 is sulphur. Its electronic configuration is 2, 8, 6. Since the valence shell in this element is 3, hence, it is present in the 3rd period of the periodic table. Also, it is 2 electrons short of the electronic configuration of the nearest noble gas (argon, electronic configuration 2, 8, 8). Hence, its valency is 8 – 6 = 2. Since the number of valence electrons are 6, it belongs to group 16 of the periodic table (10 + 6 = 16).

4. **a.** Bromine has the largest atomic radius. This is because F, Cl and Br belong to the 17th group of the periodic table, and as we go down a group, the atomic size increases.

b. F is the most reactive. This is because in case of non-metals, the reactivity decreases with increase in size. Fluorine is the first member of group 17. Hence, it is most reactive.

5. The elements with atomic numbers 12 and 38 have physical and chemical properties similar to calcium. These elements are magnesium (atomic number 12) and strontium (atomic number 38). This is because these elements are present in group 2 of the periodic table and have 2 electrons in their valence shells. As a result, they exhibit similar chemical properties.

6. We are given that electrons in the atoms of four elements A, B, C and D are distributed in three shells. Hence, all the elements belong to the third period of the periodic table. Since elements A and D have 1 and 7 electrons respectively in their valence shells, their electronic configurations are:

A = 2, 8, 1

D = 2, 8, 7

The compound formed between A and D will be an ionic compound and its chemical formula will be AD. Since A is Na and D is Cl, therefore, AD is NaCl.

7. **a.** periodic table, atomic number

b. group, electronic configuration, valence electrons

c. elements, noble gas

d. 32, 55, 86

8. **a.** Magnesium, **b.** Metal

9. The repetition of similar properties after regular intervals is called periodicity. The repetition of similar outer electronic configuration after certain regular intervals is the cause of periodicity.

10. Reactivity of metals increases with increase in metallic character and the reactivity of non-metals increases with increase in electronegative or non-metallic character.

11. **a.** Rb **b.** Ge **c.** K **d.** Sn

Electronegativity of elements decreases on moving down a group and increases in a period on moving from left to right.

12. **a.** S **b.** Ar **c.** Al **d.** Rb

The atomic radii of elements increases with increase in atomic number on moving from top to bottom in a group and decreases on moving from left to right in a period.

13. The elements of group 1, 2 and 13–18 are known as representative elements. They are called so because the elements in these groups have predictable patterns that represent a wide range of properties.

14. The electron affinities of Be and Mg are almost zero because these have completely filled subshell electronic configuration and the added electron is accommodated in higher energy subshell.

C. Short Answer Type-II Questions

1. Because the noble gases were not discovered and hence the number of elements in both periods was less by one.

2. The element with atomic number 118 is ununoctium. It is also known as oganesson. It is a solid at room temperature. It belongs to 7th period and 18th group of periodic table.

3. The electronic configuration of an element can help to determine its valency. If the number of valence electrons present in an atom of an element is ≤ 4, then the valency of that element is the same as the number of valence electrons. However, if the number of valence electrons is > 4, then the valency of that element is 8-number of valence electrons. The element with atomic number 9 is fluorine. Its electronic configuration is 2, 7. So, the valency of fluorine would be (8 – 7) = 1.

4.

Property	Mendeleev's prediction for eka-Silicon	Found for germanium
Atomic mass	72.0	72.3
Colour	Dirty grey	Greenish-white
Specific gravity (ml)	0.073	0.076
Density	5.5	5.47
Atomic volume	13 cm^3	13.22 cm^3
Formula for chloride	$EsCl_4$	$GeCl_4$
Density of chloride(g/ml)	1.9	1.887
Boiling point of chloride	< 100 °C	86 °C
Formula of oxide	EsO_2	GeO_2
Density of oxide	4.7	4.703
Property of oxide	EsO_2 will be insoluble in acids	GeO_2 is insoluble in acids
Property of sulphide	EsS_2 will be insoluble in water and soluble in ammonium sulphide solution	GeS_2 is insoluble in water and soluble in ammonium sulphide solution
Property of metal	Es will have slight reactivity with acids and will not be attacked by alkali such as NaOH, KOH.	Ge is not soluble in HCl or NaOH.Ge is soluble in HNO_3.

5. The demerits of Mendeleev's periodic table are:

i. The position of hydrogen was not correctly defined. It was placed in group I although it resembles both the group I elements – the alkali metals and the group VII elements – the halogens, in their properties.

ii. In some cases Mendeleev placed elements according to their similarities in properties and not in increasing order of their atomic masses. Thus, the position of these elements was not justified, for example, cobalt (atomic mass 58.9) was placed before nickel (atomic mass 58.6).

iii. Isotopes were not given separate places in the periodic table although Mendeleev's classification is based on the atomic masses.

iv. Some similar elements were grouped separately while some dissimilar elements were grouped together. For example, copper and mercury are similar in their properties but were placed separately. Copper was placed in group I although it did not resemble the elements of this group.

6. Electronegativity is the tendency of an atom in a molecule to attract a shared pair of electrons towards itself.

Electron affinity is the energy released when an isolated gaseous atom accepts one electron to form an isolated gaseous negative ion.

7. The arrangement of elements in the increasing order of atomic number is

$$Z < Y < X$$

This is because all the three elements belong to group 1 and as we move down a group, the atomic number and atomic size, both increase.

8. In the modern periodic table, the elements are arranged in the order of increasing atomic numbers and not increasing atomic masses. In case of potassium and argon, the atomic mass of argon is 39.9 and that of potassium is 39.1. However, the atomic number of potassium is more than that of argon. Similarly, the atomic mass of nickel (58.71) is lower than that of cobalt (58.93). Yet, it is placed after cobalt in the periodic table because its atomic number is greater than that of cobalt.

9.

Mendeleev's Periodic Table	Modern Periodic Table
Elements were arranged in increasing order of atomic masses.	Elements are arranged in increasing order of atomic numbers.
There are 8 groups.	There are 18 groups.
Each group is divided into subgroups a and b.	Groups are not divided into subgroups.
The group for noble gases was not present, as noble gases were not discovered at that time.	A separate group, i.e. group 18 is present for noble gases.
There was no place for isotopes.	This problem was rectified, as slots are determined on the basis of atomic number.

10. In the modern periodic table, there are 18 vertical columns known as Groups and 7 horizontal rows known as Periods.

Metallic character increases on moving down a group in the Modern Periodic table. As we move down the group, the electrostatic attraction between the nucleus and the outermost electron decreases due to an increase in the distance between them. This happens because on moving down the group a new shell is added. So, the valence electron can be easily lost by the element, thereby metallic character increases on moving down a group.

The size of atomic radius decreases on moving left to right in a horizontal row. When, we move across a period, the number of electrons in the same shell increases. This leads to the greater electrostatic attraction between the nucleus and the outermost electron. This increased attraction pulls the outermost electron closer to the nucleus, thereby decreasing the atomic size.

11. An element whose atomic number is 20 is calcium. Whereas element whose atomic number is 17 is chlorine.

Calcium is placed in period 4 and group 2. On the other hand, chlorine is placed in period 3 and group 7.

Therefore, element P is calcium and element Q is chlorine.

The compound formed when P reacts with Q is $CaCl_2$. The chemical reaction is as follows.

$$Ca + Cl_2 \longrightarrow CaCl$$

12. Electronic configuration of X – 2, 8, 6

i. Since 'X' has three energy shells and period number of an element is equal to the number of energy shells, X belongs to 3rd period.

ii. X has 6 valence electrons it belongs to group 16.

iii. Valency will be 2. To acquire noble gas configuration it will gain 2 electrons.

13. The electronic configuration of element X is 2,8,2. Now, as it has 2 electrons in its outermost shell or in its valence shell, it belongs to the period 3 (group 2) of the modern periodic table. The element is Magnesium (Mg). Similarly, the electronic configuration of element Y is 2,8,6. Now, as it has 6 electrons in its outermost shell or in its valence shell, it belongs to the period 3 (group 6) of the modern periodic table. The element is Sulphur (S).

They will form ionic bond since X is a metal and Y is a non-metal.

The chemical compound formed by them is MgS.

14. The elements in a group tend to have similar physical and chemical properties because of their similar outer shell electron structure.

a. Valency of first group elements is 1 and that of oxygen is 2. Hence, oxide of first group is X_2O.

e.g., H ⨯ O
1 ↙↘ 2 (Criss cross)

H_2O is the oxide.

b. Group 13 elements has a valency of 3 and that of halogen is 1. Hence, halide of group 13 is MX_3.

e.g., B ⨯ Cl
3 ↙↘ 1 (Criss cross)

BCl_3 is the halide.

c. The valency of the group 2 elements is 2 and that of group 17 elements is 1. Group 2 loses electrons and group 17 accepts electrons. Hence, compound formed is AB_2.

e.g., Mg ⨯ Cl
2 ↙↘ 1 (Criss cross)

$MgCl_2$ is the compound.

15. The atomic number is the number of protons whereas atomic mass is the sum of the number of protons and neutrons in the nucleus.

Atomic number increases regularly by one in going from one element to the next element but atomic mass does not vary regularly must of the chemical properties of elements depend upon valence electrons and electric configuration of an atom which in turn depends on the number of electrons i.e, atomic number. That's why the atomic number of an element is considered to be more appropriate than its atomic mass for a chemist.

Element X (Aluminium) having atomic number 13.

Electronic configuration:

Valence electron of X (Al) = 3

Group No.= 10 + valance electron

= 10 + 3 = 13 [valance electron of Al = 3]

As the Principal quantum number is 3 so, aluminium is 3rd Period element.

Hence, it becomes easy to locate Aluminium in the periodic table and by finding electronic configuration using the atomic number, to understand its characteristic properties like it has metallic properties.

16. **a.** An element's valency is determined by the number of electrons in its outer shell. Hence, the number of valence electrons obtained from the electronic configuration of the element gives the valency i.e., the number of electrons lost, gained or shared by the element to attain the noble gas configuration.

b. X : 2, 8, 5 = 15

Element 'X' Has 5 electrons in the outermost shell. Hence, its valency is

8 – 5 = 3

17. The distance from the centre of the nucleus to the outermost shell is called atomic radius. On moving from left to right in a period in the periodic table, the nuclear charge increases by one unit in each succeeding element, while the added electron enters the same shell. As a result, the electrons of all the shells are strongly pulled towards the nucleus. Hence, there is a steady contraction in atomic radius from left to right.

On moving down a group, new shells get added at each succeeding element. Hence, the electrons in the valence shell of each succeeding element lie farther and farther away from the nucleus. Consequently the attraction of the nucleus for the electrons decreases and as a result the atomic radius increases with increase in atomic number.

18. Electron affinities increase as we move from left to right in a period. This is because as we move from left to right in period, the electronegativity of atoms increases. Hence, it becomes easier for atoms to gain electrons and complete their octets. As a result, the amount of energy released on the gain of electron(s) increases.

19. On moving from left to right in a period in the periodic table, the nuclear charge increases by one unit in each succeeding element, while the added electron enters the same shell. As a result, the electrons of all the shells are strongly pulled towards the nucleus. Hence, there is a steady contraction in atomic radius from left to right. Hence, on moving from sodium to chlorine, the atomic radius decreases progressively.

20. a. Element 119 is expected to be the first element in the eighth period and is expected to be an alkali.

b. It would be a metal.

c. The outer electronic configuration would be 8s1. It has 1 electron in outermost s orbital.

d. i. It should show the Characteristic +1 oxidation state of alkali metal.

ii. It may be a liquid at room temperature.

21. The properties of the elements are periodic functions of their atomic masses. Three anomalies in Mendeleev's periodic table are that there is no place for isotopes of an element and the position of hydrogen is controversial.

22. Modern periodic law states that the physical and chemical properties of elements are periodic functions of their atomic numbers. It differs from Mendeleev's periodic law which takes atomic masses into consideration rather than atomic numbers.

23. a. We are given that the element belongs to the 3rd period and group 16 of the periodic table. Hence, the element has 16 – 10 = 6 valence electrons. Its valency is 2(8 – 6 = 2). Also, the electrons in this element are distributed in three shells.

b. When X reacts with hydrogen, it forms a compound with the molecular formula H_2X. The electron dot structure of the compound is

c. The element X is sulphur. It is a non-metal.

24. The tendency of an element to lose electrons and form positive ion is called metallic character. It is also known as electropositive character.

a. On moving down a group, the metallic character of elements increases.

b. On moving from left to right in a period, the metallic character decreases.

25. a. The valency of group 1 elements is 1. Hence, the formula of their oxides should be M_2O, where M refers to group 1 elements.

b. The valency of group 13 elements is 3. Since the valency of halogens is 1, therefore, the formula of their halides should be EX_3, where E refers to group 13 elements and X refers to halogens.

c. The valencies of group 2 and group 16 elements are 2. So, when the elements of the two groups combine, they form compounds of the type AB. Here, A refers to elements of group 2 and B refers to elements of group 16.

26.

	P	Q
a.	The number of electrons in P is one less than the number of electrons in Q.	The number of electrons in Q is one more than the number of electrons in P.
b.	P is bigger in size as compared to Q.	Q is smaller in size than P.
c.	P is more metallic than Q.	Q is less metallic than P.
d.	P has more tendency to lose electrons.	Q has more tendency to lose electrons.
e.	Oxides of P is P_2O.	Oxide of Q is QO.
f.	Chloride of P is PCl.	Chloride of Q is QCl_2.

27. a. Lithium **b.** Fluorine **c.** Lithium **d.** Neon **e.** Fluorine

28. a. C **b.** B **c.** B

29. a. Sulphur **b.** non-metal **c.** 6

30. In the modern periodic table, the columns are known as groups and the rows are known as periods.

a. Since X and Y are present in the same period and belongs to group 1 and 2 respectively, therefore, X is bigger in size than Y.

b. X is more metallic than Y.

c. The valency of X will be 1, since it belongs to group 1. The valency of Y will be 2, since it belongs to group 2.

d. The chemical formula of chloride of X will be XCl, and that of Y will be YCl_2.

31. Argon has been rightly placed in the periodic table before potassium even though its atomic mass is higher than that of potassium because its atomic number is 18 which is less than that of potassium, i.e. 19. Periodic table is based on atomic number and not atomic mass.

32. The amount of energy required to remove the most loosely held electron from an isolated gaseous atom is called ionisation energy. Electron affinity is the energy released when an isolated gaseous atom accepts one electron to form an isolated gaseous negative ion. The distance from the centre of the nucleus to the outermost shell is called atomic radius.

33. a. Br **b.** carbon **c.** Be **d.** Cl **e.** Ne **f.** Hg

34. a. Ba **b.** Al **c.** Cl

35. a. Correct statement.

b. Periods have elements with consecutive atomic numbers.

c. Elements in the same group have same valency.

d. Isotopes are atoms of the same element.

36. The limitations of Newlands law of Octaves were:

i. It was applicable only upto calcium because after calcium every eighth element did not possess properties similar to that of first.

ii. It was assumed by Newlands that only 56 elements existed in nature and no more elements would be discovered in future. However, new elements were discovered whose properties did not fit into the law of Octaves.

iii. Newlands put some elements of different properties in the same slot.

37. a. Element X has more metallic character.

b. The valency of element X is 1 while that of element Y is 3.

c. We are given that element X and Y are present in the 3rd period of the periodic table. As we move across a period from left to right, the atomic number increases while the size of element decreases. Since element Y has higher atomic number than element X, therefore, it is placed after X in 3rd period, and so is smaller in size than X.

38. a. K **b.** Kr **c.** Ga

39. a. O < Ne < P < Mg < K

b. He < S < Si < Ar < Ca

c. O < C < B < Ne < Al

d. F < N < Be < Mg < Na

40. Ga 124, Na 154, K 202, B 90, Mg 145, C 77

D. Long Answer Type Questions

1. a. Dobereiner Periodic Table

Advantage: Dobereiner noticed that the elements could be arranged in the order of increasing atomic mass in the groups of three in which the atomic mass of the middle element was approximately the arithmetic mean of the atomic masses of the other two elements.

Limitation: Dobereiner's classification was not applicable to all known elements but was limited to only a few elements.

Newlands' Periodic table

Advantage: When elements are arranged in the order of increasing atomic masses, the physical and chemical properties of every eighth element are a repetition of the first element.

Limitation: The law of octaves worked well only for lighter elements and could not be extended to elements of atomic masses higher than that of calcium since after Ca every eighth element did not exhibit properties similar to that of the first.

Mendeleev's Periodic Table

Advantage: Elements with similar properties could be grouped. He predicted the existence of new elements that had not been discovered at that time.

Limitation: Mendeleev did not provide separate places for the isotopes of an element. Isotopes were discovered long after Mendeleev proposed his Periodic Table.

b. Name of the scientist: Henry Moseley

c. Modern periodic law: The physical and chemical properties of elements are a periodic function of their atomic numbers.

2. a. E element, that is Silicon, will form only covalent compounds, it has 4 valence electrons and needs 4 more electrons to become stable.

b. B element is a non-metal with valency 2, which is oxygen, it needs only 2 electrons to attain stable configuration.

c. D element is a metal with valency 2, which is magnesium. It loses two electrons to attain stable configuration.

d. Out of H, C and F, F has the largest size since size increases down the group. F is Argon, which occupies 3 energy shells while H and C occupy 1 and 2 energy shells respectively. Thus, argon's atomic radius is the largest.

e. H, C and F belong to Noble gases, as their outermost shell is complete and thus these elements are stable.

3. Atomic Size is the distance between the centre of an atom i.e from the nucleus to the outermost (valence) shell of that atom.

Atomic size is measured in Angstroms, where 1 Angstrom = 10^{-10}m.

In the modern periodic table, the atomic size of elements increases down the group, and the atomic size decreases along the period from left to right.

On moving down a group, a new shell of electrons is added in each succeeding element. Hence, the electrons in the valence shell of each succeeding element lie farther and farther away from the nucleus. Consequently, the attraction of the nucleus for the electrons decreases and as a result, the atomic radius increases with increase in atomic number. But the nuclear charge of elements also increases. This produces a contractive effect on the atomic radius. The increase in the atomic radius due to the addition of new shell is so large that it outweighs the contractive effect of the increased nuclear charge. As a result, the atomic radius increases on moving down a group from top to bottom.

The atomic radii of elements decrease with increase in atomic number on moving from left to right in a period. On moving from left to right along a period, the nuclear charge increases by one unit in each succeeding contraction in atomic radius from left to right in a period. Thus, in any period, the alkali metal atom such as Li, Na, K, etc. has the largest atomic radius while the halogen atom has the smallest atomic radius. The atomic radius suddenly increases for the noble gas atom due to the interelectronic repulsion within a shell Francium has the highest atomic radius and hydrogen has the smallest atomic radius.

4. a. i. Explanation for the positions of some elements: Mendeleev placed the following pairs of elements in the reverse order of their atomic masses: Ar and K; Co and Ni; Te and I. Argon has an atomic mass of 40 u and potassium has an atomic mass of 39 u. Thus, according to Mendeleev's periodic law, argon should be placed after potassium. On the contrary, Moseley's studies assigned an atomic number 18 to argon and 19 to potassium and hence placed argon before potassium. Similar irregularity of inversion of positions was eliminated for the other pairs: Co, Ni; Te, I.

ii. Explanation for the position of isotopes: Since the isotopes of an element have the same number of protons, their atomic number is also the same. Hence, in spite of having different atomic masses, the isotopes of an element are assigned the same position in the Periodic Table.

iii. Positions of elements having identical properties in different groups: Copper and mercury exhibit similarity in chemical properties. But they are placed in different groups (Cu in Group I B and Hg in Group II B) since their atomic numbers are different. Similarly, barium and lead having similar properties are placed in different groups (Ba in Group II A and Pb in Group IV A) since their atomic numbers are different.

b. i. Variation of metallic and character in a period: On moving from left to right in a period, the metallic character decreases. For example, the metallic character of elements of third period decreases as follows:

Period 3	Na	Mg	Al	Si	P	S	Cl	Ar
Nature	Metal	Metal	Metal	Semi-metal	Non-metal	Non-metal	Non-metal	Non-metal

Metallic character decreases →

Thus, we find sodium at the extreme left is a metal and argon at the extreme right is a non-metal. The above trend is also true in the elements of other periods.

ii. Variation of metallic character in a group: On moving down a group, the metallic character of elements increases. This is due to the increase in atomic radius on moving down the group. Since the distance between the nucleus and outermost electrons increases on moving down a group, the force of attraction between nucleus and electrons decreases and less energy is required to lose electrons. The order of increasing metallic character in the elements of Groups 1, 2 and 14 is shown as follows.

Metallic character increases

Group 1

Li Na K Rb Cs Fr

Metallic character increases

Group 2

Be Mg Ca Sr Ba Ra

Metallic character increases

Group 14

C Si Ge Sn Pb

In Group 14, carbon is a non-metal, silicon and germanium are semi-metals*, and tin and lead are metals. Hence, the metallic character increases and non-metallic character decreases on moving down a group.

5.

Element	Valence electrons	Period	Group
A	1	3	1
B	3	3	3
C	5	3	5
D	7	3	7

Electronic configuration of B: $1s^2 2s^2 2p^6 3s^2 3p^1$

Electronic configuration of D: $1s^2 2s^2 2p^6 3s^2 3p^5$

Element: B D

Valency: 3 1

So, the molecular formula will be BD_3

6. a. Mendeleev's classification of elements is based on atomic mass of elements.

Grouping of elements which exhibited similar properties placed under the same vertical column called. group

Law of chemical periodicity: The physical and chemical properties of elements are periodic functions of their atomic masses.

Position of hydrogen: Mendeleev placed hydrogen in Group I A. But hydrogen exhibits close similarities in properties with the elements of both Group I A and VII A. Hence, the position of hydrogen in the Mendeleev's Periodic Table is not correctly defined.

b. In the modern periodic table, the atomic size of elements increases down the group, and the atomic size decrease along the period from left to right.

On moving down a group, a new shell of electrons is added in each succeeding element. Hence, the electrons in the valence shell of each succeeding element lie farther and farther away from the nucleus. Consequently, the attraction of the nucleus for the electrons decreases and as a result, the atomic radius increases with increase in atomic number. But the nuclear charge of elements also increases. This produces a contractive effect on the atomic radius. The increase in the atomic radius due to the addition of new shell is so large that it outweighs the contractive effect of the increased nuclear charge. As a result, the atomic radius increases on moving down a group from top to bottom.

The atomic radii of elements decrease with increase in atomic number on moving from left to right in a period. On moving from left to right along a period, the nuclear charge increases by one unit in each succeeding contraction in atomic radius from left to right in a period. Thus, in any period, the alkali metal atom such as Li, Na, K, etc. has the largest atomic radius while the halogen atom has the smallest atomic radius. The atomic radius suddenly increases for the noble gas atom due to the interelectronic repulsion within a shell Francium has the highest atomic radius and hydrogen has the smallest atomic radius.

7. a. The valency of an element is determined by the number of electrons in its outer shell. Therefore, the number of valence electrons obtained from the electronic configuration of the element gives the valency i.e., the number of electrons lost, gained, or shared by the element to attain a noble gas configuration.

The valency of an element of atomic number 9 (Electronic configuration: 2, 7) would be 1 (8 – 7 = 1) since the number of valence electrons in its outer shell is 7 so it needs only one electron to attain the noble gas configuration.

b. i. Element D (19) has one electron in its outermost shell. Its electronic configuration is 2, 8, 8, 1.

ii. Elements A (4) and E (20) have two electrons in their outermost shells. Electronic configuration of A: 2, 2

Electronic configuration of E: 2, 8, 8, 2

As both of them have a valency of two,

hence, they belong to group 2 of the periodic table.

iii. Elements A (4) and B (9) belong to the second period, and elements **D (19) and E (20)** belong to the fourth period of the periodic table.

As the effective nuclear charge that pulls the out ermost electron closer to the nucleus increases from left to right in a period, the atomic radii of the elements decrease.

Therefore, A (4) has a bigger atomic radius than B (9) and D (19) has a bigger atomic radius than E (20).

8. a. Two limitations of Newlands' Law of Octaves

i. The law of octaves worked well only for lighter elements and could not be extended to elements of atomic masses higher than that of calcium since after Ca every eighth element did not exhibit properties similar to that of the first.

ii. Newlands assumed that only fifty-six elements existed in nature with no scope for discovery of new elements in future. Subsequently, quite a large number of new elements were discovered, the properties of which did not fit into Newlands' law of octaves.

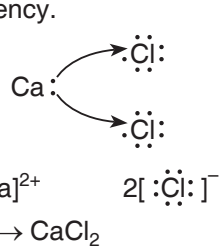
b.

Element A	Element B
Atomic no – 20	Atomic No – 17
Electronic Configuration – 2,8,8,2	Electronic configuration –2,8,7
It is Calcium	It is Chlorine

When both elements react together they will form calcium chloride:

$$Ca + Cl_2 \longrightarrow CaCl_2$$

A has two extra electrons, hence A has +2 valency. B needs 1 electron to be stable, hence B has -1 valency.



Type of bond – ionic bond

9. a. i. Metallic character decreases across a period. For example, metallic character of elements of third period decreases from Na which is a metal to S, which is a semi-metal to Ar, which is a non-metal.

ii. Metallic character increases while going down a group. For example, in group 14, carbon is a non-metal, silicon and germanium are semi-metals and tin and lead are metals.

b. Since the element X belongs to the group 14, it has 4 valence electrons. Therefore, the formula of its chloride compound is XCl_4. The nature of bonding is covalent bond.

c. We are given that the element X has mass number 35 and the number of neutrons are 18. So, the number of protons would be 35 – 18 = 17. Since the number of protons is equal to the number of electrons, hence, the number of electrons in X = 17. The element is chlorine. Its electronic configuration is 2, 8, 7. It belongs to the 7th group and 3rd period of the periodic table. Its valency is 1.

10. a. The vertical columns of elements in the Periodic Table are called groups. There are eighteen groups in the Modern Periodic Table and these groups are numbered as 1, 2, 3, … 18 from left to right across the Periodic Table.

The electrons present in the outermost shell of an atom of an element are called its valence electrons. They are so called because the electrons in the outermost shell determine the valency of an element.

The atomic radii thus atomic size of elements increase with increase in atomic number on moving from top to bottom in a group. On moving down a group, a new shell of electrons is added in each succeeding element. Hence, the electrons in the valence shell of each succeeding element lie farther and farther away from the nucleus. Consequently, the attraction of the nucleus for the electrons decreases and as a result, the atomic radius increases with increase in atomic number. But the nuclear charge of elements also increases. This produces a contractive effect on the atomic radius. The increase in the atomic radius due to the addition of new shell is so large that it outweighs the contractive effect of the increased nuclear charge. As a result, the atomic radius increases on moving down a group from top to bottom

The atomic radii thus the atomic size of elements decrease with increase in atomic number on moving from left to right in a period . On moving from left to right along a period, the nuclear charge increases by one unit in each succeeding element, while the added electron enters the same shell. As a result, the electrons of all the shells are strongly pulled towards the nucleus. Hence, there is steady contraction in atomic radius from left to right in a period. Thus, in any period, the alkali metal atom such as Li, Na, K, etc. has the largest atomic radius while the halogen atom has the smallest atomic radius. The atomic radius suddenly increases for the noble gas atom due to the interelectronic repulsion within a shell. Francium has the highest atomic radius and hydrogen has the smallest atomic radius.

On moving down a group, the metallic character of elements increases. This is due to the increase in atomic radius on moving down the group. Since the distance between the nucleus and outermost electrons increases on moving down a group, the force of attraction between nucleus and electrons decreases and less energy is required to lose electrons. The non-metallic character decreases on moving down a group since the tendency to gain electrons decreases on moving down a group.

On moving from left to right in a period, the metallic character decreases and non metallic character increases. The non-metallic character increases across a period from left to right since the tendency to gain electrons increases across a period from left to right.

b. An element whose atomic number is 14 is silicon and it is a semi-metal. Therefore, we can conclude that it will not have metallic properties. It is in the 3rd period and 14th group. Metallic character decreases as we move from left to right in a period.

11. a. fluorine

b. carbon

c. boron

d. lithium

e. CO_2

12. We are given that the compound formed between A and G is an ionic compound, and is added to all vegetable dishes during cooking. Thus, this compound is NaCl. Also, it is given that the oxides of A and B are basic in nature while that of E and F are acidic. So, A is sodium and G is Cl.

a. The listed elements belong to group 1, 2, 13–18 of the periodic table. These elements belong to the 3rd period.

b. Compound B is a metal and F is a non-metal. The nature of compound formed between the two would be ionic.

c. Elements A and B are definitely metals, since their oxides are basic.

d. Elements G and H will exist as gases at room temperature.

e. The formula of compound will be CG_3.

13. a. The amount of energy required to remove the most loosely held electron from an isolated gaseous atom is called ionisation energy.

b. Electron affinity is the energy released when an isolated gaseous atom accepts one electron to form an isolated gaseous negative ion.

c. The distance from the centre of the nucleus to the outermost shell is called atomic radius. Ionisation energy increases as we move across a period and decreases on moving down the group. Electron affinity increases as we move across a period and decreases as we move down a group. Atomic radius decreases along a period and increases down a group. The units of ionisation energy and electron affinity are kJ/mole while that of atomic radius is picometre (pm).

14. a. K, **b.** Br, **c.** Kr, **d.** Se, **e.** K, **f.** K

15. The usefulness of periodic table is as follows: The table is based on atomic numbers of elements. This is a more basic quantity than the atomic mass concept used previously. The table shows why elements in the same group display same properties. The table also shows how and why the properties of elements differ in the same period. The periodicity is related to electron configuration. This is displayed very clearly by the periodic table. All chemical and physical properties are an expression of the electron configuration of the elements. Hence, the periodic table is very orderly and follows the fundamental electronic structure of the elements to categorise them.

16. Electron affinity is the energy released when an isolated gaseous atom accepts one electron to

form an isolated gaseous negative ion. Factors affecting electron affinity are atomic radius, nuclear charge and electronic configuration. The electron affinity of elements decreases on moving down a group and it increases on moving across a period.

17. The amount of energy required to remove the most loosely held electron from an isolated gaseous atom is called ionisation energy. The factors affecting ionisation energy are atomic radius and nuclear charge. The greater the atomic radius, the lesser is the ionisation energy and the greater the nuclear charge, higher is the ionisation energy. The ionisation energy increases on moving across a period and it decreases on moving down a group.

18. **a.** I, **b.** A, **c.** B,
d. I, **e.** Halogens, **f.** C, D, F
g. B.

19. **a.** Ca, **b.** Ba, **c.** $Ra(OH)_2$,
d. BaO, **e.** Ra

20. **a.** Si, Ge, **b.** C, **c.** $GeCl_2$, GeO_2
d. Pb, **e.** C

21. **a.** Li, F **b.** Li, Be **c.** Ne,
d. B, **e.** N, O, F **f.** Li

22. Mendeleev's periodic table was based on atomic masses of elements, in which the elements were arranged in the order of increasing atomic masses. In his table, Mendeleev was unable to give fixed position to hydrogen and isotopes. Also, the increasing order of atomic mass of the elements was not always regular from one to its next. However, in the modern periodic table, the elements are arranged in the order of increasing atomic number. Hence, all isotopes are placed in one slot. Also, the atomic number of elements increases in a regular fashion, which solves the problem of irregular increase in atomic mass.

23. Mendeleev is dubbed "father" of the Periodic Table. But it is in fact the work of several scientists through trial and error that has given the Table its present form. With the discovery of many elements, approximately sixty, scientists desired for a way to organise them.

John Dobereiner led the way to a method to find order amongst the elements in 1829. This German chemist presented his theory of the Law of Triads. From his observations of atomic weight of element bromine, which lies between that of chlorine and iodine (the same pattern can be found in atomic weight of strontium, which lay halfway between calcium and barium), he concluded that there is a relationship between these elements, in that the middle element in the triad (the name given to the groups) consist of an atomic weight that is the average of the other two elements in that group.

Alexandre Beguyer de Chancourtois continued the path to find order within the elements. In 1862, he proposed his theory about the "telluric screw" to describe the relationship between the known elements. This "telluric screw" consists of a cylinder on which was drawn a descending spiral line. At intervals along the line, he plotted each element according to its atomic weight (he also mistakenly plotted some ions and compounds – these are not considered as elements). He concluded from his observation that the properties of the elements would repeat itself when read off in vertical columns down the cylinder – after every sixteen units of atomic weight the properties of the matching elements exhibit similarities with the ones vertically above them.

The next scientist to contribute to the organisation of the Periodic Table is chemist John Newlands, who propose the theory of periodicity in the properties of elements (Law of Octaves). He observes that by listing the elements in ascending order of atomic weights, in vertical lines of seven, the properties of the elements along the corresponding horizontal lines are parallel. Intervals of eight elements l https://www.msn.com/en-in/feed?rc=1 ead to a correlative chemical property appearing again. Newlands applies the theory of Octave of music to the order of the elements, this can also be consider as a "crack" because it's an individual preference to relate chemical theories to another topic that the individual can relate too, in this case music.

A major contributing factor that aids Mendeleev in his quest for a structure in the elements is the great chemist Cannizzaro. Cannizzaro made a good assumption that the equivalent weight method was based on a ruinous misapprehension.

Moseley in 1911 improved the Periodic Table by arranging the elements according to increasing atomic numbers and not by atomic mass (what Mendeleev did).

24.

Mendeleev's periodic table	Modern periodic table
Elements are arranged in the increasing order of their atomic masses.	Elements are arranged in the increasing order of their atomic numbers.

There are a total of 7 groups (columns) and 6 periods (rows).	There are a total of 18 groups (columns) and 7 periods (rows).
Elements having similar properties were placed directly under one another.	Elements having the same valence shell are present in the same period while elements having the same number of valence electrons are present in the same group.
The position of hydrogen could not be explained.	Hydrogen is placed above alkali metals.
No distinguishing positions for metals and non-metals.	Metals are present at the left hand side of the periodic table whereas non-metals are present at the right hand side.

25. a. The tendency to lose electrons is called electropositivity. On moving across a period the electropositivity decreases whereas on moving down a group, the electropositivity increases.

b. $Mg(NO_3)_2$, $MgSO_4$, $Mg_3(PO_4)_2$. It belongs to the second group of periodic table. It will form an ionic bond because it has a tendency to lose its outer electrons and become an ion.

26. a. E,

b. D,

c. B,

d. Noble gases,

e. D will have a higher atomic radius because on moving across a period, the atomic radius decreases.

27. i. Metallic character decreases across a period.

ii. Metallic character increases while going down a group.

On moving down a group, the metallic character of elements increases. This is due to the increase in atomic radius on moving down the group. Since the distance between the nucleus and outermost electrons increases on moving down a group, the force of attraction between nucleus and electrons decreases and less energy is required to lose electrons. The non-metallic character decreases on moving down a group since the tendency to gain electrons decreases on moving down a group.

On moving from left to right in a period, the metallic character decreases and non metallic character increases. The non-metallic character increases across a period from left to right since the tendency to gain electrons increases across a period from left to right.

E. Source-based / Case-based / Passage-based / Integrated Assessment Questions CBQ

1. a. ii. **b.** i. **c.** iii. **d.** ii. **e.** iv.

2. a. i. **b.** iv. **c.** i. **d.** iii. **e.** iv.

3. a. iv. **b.** iv. **c.** iii. **d.** ii. **e.** iv.

4. a. ii. **b.** i. **c.** iii. **d.** iv. **e.** i.

F. Higher Order Thinking Skills (HOTS) Questions

1. Atomic mass of the middle element B = 31

Atomic mass of element A = 14

Let the atomic mass of element C be X.

According to Dobereiner, the atomic mass of the middle element must be the average of the other two elements.

Hence, $$\frac{14 + X}{2} = 31$$

$$14 + X = 62$$

$$X = 62 - 14 = 48$$

A is Nitrogen, B is Phosphorus and C should be titanium if we consider the atomic mass. However, in actual, C is arsenic.

2.

Element	Nature of Element
Sodium	Metal
Magnesium	Metal
Aluminium	Metal
Silicon	Metalloid
Phospohorus	Non-metal
Sulphur	Non-metal
Chlorine	Non-metal
Argon	Non-metal

3. Atomic number, Moseley

4. Li < Na < K < Rb < Cs. All these elements belong to the same group. The tendency to lose electrons increases down a group because of addition of new shells. The addition of new shells leads to increase in distance from the nucleus.

5. **a.** F, **b.** Ne, **c.** Li, **d.** O

6. **a.** Chlorine, **b.** Na, **c.** Fluorine

7. **a.** Ca, 20, **b.** Metal, **c.** 2, **d.** Ionic

8. O < N < C < B < Be < Li. All these belong to the same period.

9. **a.** (i), **b.** (iii), **c.** (iv), **d.** (ii)

10. **c.** Al

11. **i.** 2, **ii.** 2, **iii.** 2, **iv.** metal

12. **i.** Neon, **ii.** Aluminium, **iii.** Silicon

13. **i.** F, Cl, Br, **ii.** Fe, **iii.** Be, Mg, Ca, Sr

14. Do not exist in elemental form in nature. They exist as ores.

15. Electronegativity

16. Nitrogen – 2,5. Phosphorus – 2, 8, 5. Nitrogen will be more electronegative because they belong to the same group and electronegativity decreases as we move down the group.

G. Value-Based Questions (Optional)

1. **a.** A lot of elements are known and to study the properties of each element individually would be a cumbersome task. Classification of elements would allow to treat adequately the chemistry of all the elements without developing separate set of rules and theory for each element.

   b. The member of valence electrons in a group remains constant as we move along a group. If the number of valence electrons are <4, the element displays properties of a metal. If the number of valence electrons is > 4, the element displays properties of a non-metal. If the element has 4 valence electrons, the element can display properties of a metal, metalloid or a non-metal.

   c. The scientists displayed properties such as sincerity, dedication, hardworking and positive attitude.

2. **a.** The outermost shell in an atom is known as the valence shell. The electrons present in the valence shell of an atom is known as valence electrons.

   b. The valency of an element determines the chemical properties of an element. Since the valency of an element depends on the number of electrons present in the outermost shell, it is also known as the valence shell.

   c. As we move across a period from left to right, the metallic character decreases while the non-metallic character increases. So, elements on the left hand side of the periodic table form ionic chlorides while the elements on the right hand side of the table form covalent chlorides. Thus, as we move from left to right across a period, the ionic character decreases while covalent character increases.

   d. The educational values help in building the right attitude and perspective of the individuals in a society. In a similar manner, the properties of an element are determined by its electronic distribution.

3. **a.** According to the modern periodic law, the properties of elements are a periodic function of their atomic numbers.

   b. Unlike Mendeleev's periodic table, which is based on atomic masses, the Modern periodic table is based on atomic number, which is a more fundamental property for classification of elements. In Modern periodic table, there are no anomalies or gaps as were observed in the Mendeleev's periodic table.

   c. The society is indeed divided on the basis of money. As people from all social stratas live in the society, it has led to division on the basis of their income and financial status.

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1. **a.** The distance from the centre of the nucleus to the outermost shell is called atomic radius.

   b. The repetition of similar properties after regular intervals is called periodicity.

2. Mendeleev's periodic law states that the physical and chemical properties of elements are periodic functions of their atomic masses.

3. **a.** Atomic radius increases down a group.

   b. Decreases across a period.

4. Lithium (Li)

5. The noble gases are missing from Newlands' Octaves because those were not discovered at that time. If the noble gases are included in Newlands' Octaves, the arrangement will not fit in the musical scale in which the eighth note resembles the first one.

6. The tendency to lose electron is the metallic character. It decreases along a period.

7. Boron is a metal and polonium is a semi-metal.

8. K

9. kJ/mol

10. **a.** H, **b.** F and J, **c.** C, **d.** F **e.** DE, **f.** HJ_3